HISTOPATHOLOGY OF DENTAL CARIES, AND ITS PERIAPICAL SEQUELAE[1]

R. W. LEIGH, A.B., D.D.S.[2]

Washington, D. C.

CONTENTS

I. Introduction 197
II. Etiology of dental caries 201
(a). The exciting cause 201
(*b*). The predisposing causes 205
III. Localization and periodicity of caries 209
IV. Pathology of dental caries 217
V. Sequelae of dental caries 224
VI. Natural methods of increasing resistance to caries 229
VII. Dentifrices 232
VIII. So-called dental prophylaxis 235
IX. Chemotherapy, prophylactic odontotomy, filling of incipient carious cavities. 237
X. Summary 239

I. INTRODUCTION

Genuine progress in dentistry is dependent upon exact knowledge of the cause of dental caries. Preventive medicine is first concerned with studies in etiology. With the etiology of a disease or pathological process determined, a rational prophylaxis may be developed. The prevention of dental disease has not had attention commensurate with its importance, but not a little native ability and a tremendous amount of professional energy in the aggregate have been shunted into therapeutic and reparative channels. There are two fundamental reasons for this trend of professional development, which are based upon peculiar characteristics of the dental tissues. To the pathologist the outstanding characteristic of the dental tissues is

[1] Read before The New York Academy of Dentistry, New York City, November 20, 1924; and the District of Columbia Dental Society, January 13, 1925.

[2] Captain, Dental Corps, U. S. A. From the Laboratory of Pathology, Army Dental School.

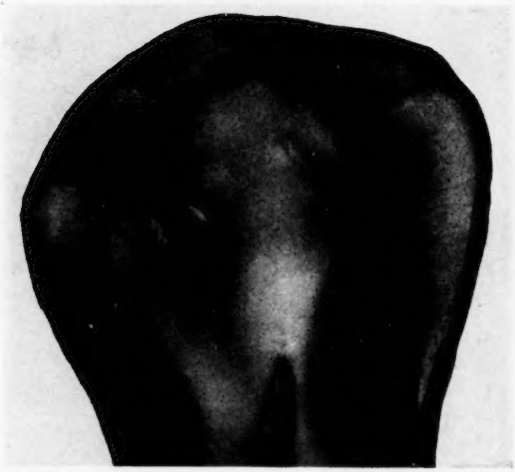

FIG. 1. Mesio-distal gross section mandibular second premolar, showing localization of caries in two occlusal pits. (Prepared by grinding and photographed by reflected light. × 10.)

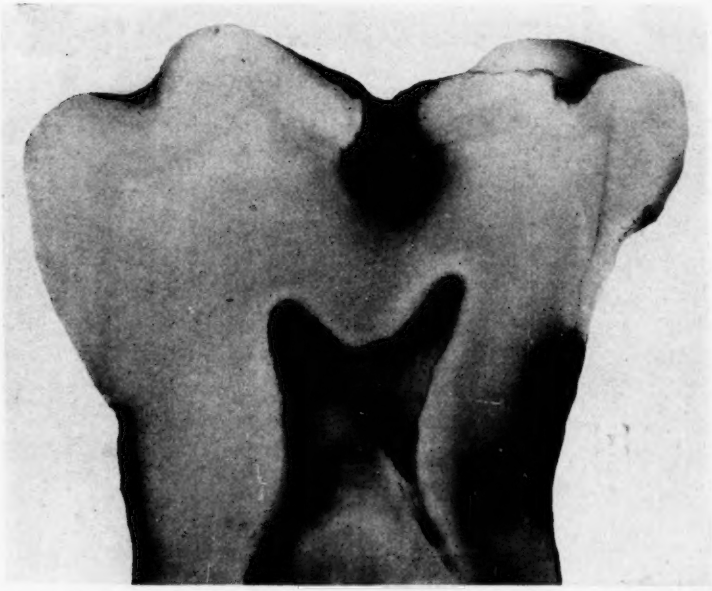

FIG. 2. Mesio-distal gross section maxillary first molar, showing localization of caries in occlusal pit, in mesial enamel surface and at bare dentin at cervix. (Prepared by grinding and photographed by reflected light. × 10.)

their utter inability to regenerate. To the skilled dental operator the most patent peculiarity of the teeth is the comparative facility with which their anatomy and function may be simulated. Thus a diseased dental tissue is permanently lost, but it is mechanically practicable to reconstruct it with foreign material. As a result of this biological condition and mechanical possibility, dentistry has developed as an art and science preëminently concerned with pros-

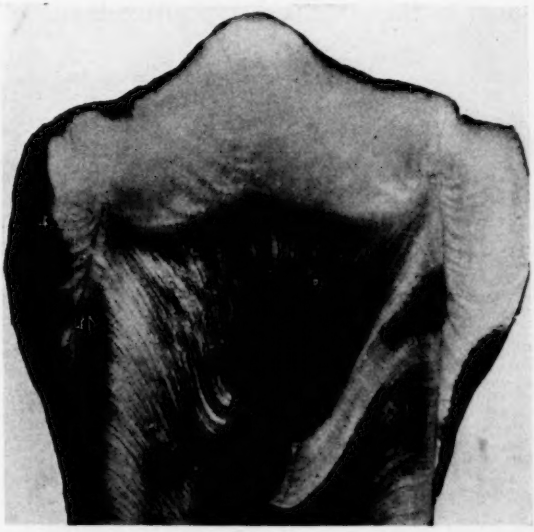

FIG. 3. Mesio-distal ground section of premolar. Partially decalcified areas of enamel, resultant from caries, permit ingress of the stain; intact enamel does not admit the stain. Area of stained dentin was exposed to the outside by a cavity not shown in this section. The "translucent zone of Miller" intervenes between carious tissue and pulpal wall. This is a sclerosis of the dentin resulting from reaction of pulp cells to the irritating caries process. (Stained with silver nitrate in bulk before sectioning. × 10.)

thetic restoration of tissues lost through disease, but the most ardent enthusiasts of the accomplishments of reparative dentistry admit that the natural tissues are incomparably superior to any handiwork.

Focal infection has been prominent during the last decade. Its consideration has brought about improved root-canal therapy, roentgenographic diagnosis, elaboration of a considerable surgical technique for the removal of local sequelae of dental focal infection,

and betterment in various phases of prosthesis. In the last few years, the baneful effects of focal infection and loss of dental tissue have awakened an unmistakable interest in the etiology and prevention of oral diseases. Both in dental science and closely allied medical and biological sciences, the etiology of dental disease is now being considered. Prevention is the goal as it is in all aspects of medicine. Dental caries is the universal dental malady; it not only destroys the hard parts, but is the forerunner either directly or indirectly of most of the other pathological conditions of the dental

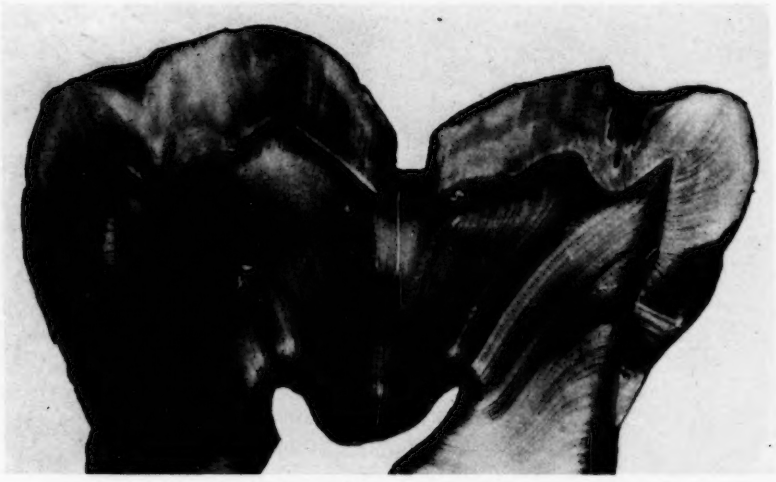

FIG. 4. Mesio-distal section of macroscopically sound molar, showing caries in central occlusal fissure and on both proximal surfaces; two structurally defective areas are also shown on occlusal surface. Both affected and loosely constructed enamel permit ingress of the stain. (Stained with silver nitrate in bulk before sectioning. × 10.)

and paradental tissues. The fundamental aim of the study of the etiology and pathology is prevention. The program of repairing and replacing diseased teeth has been uncritically accepted so long that the serious study of causal factors is regarded with indifference in some quarters. It is somewhat difficult to imagine dentistry handling caries as public health does typhoid fever, by sanitary and immunization measures before it happens.

II. ETIOLOGY OF DENTAL CARIES

(*a*). *The exciting cause*

The chemo-bacterial theory of Miller (10), which was based on considerable experimental data and supported by clinical observation, is that dental caries is produced (a) by bacterial fermentation of carbohydrate food debris adherent to teeth, resulting in acids which decalcify the teeth, with (b) a simultaneous invasion of the organic content of the hard parts by bacteria, followed by proteolysis

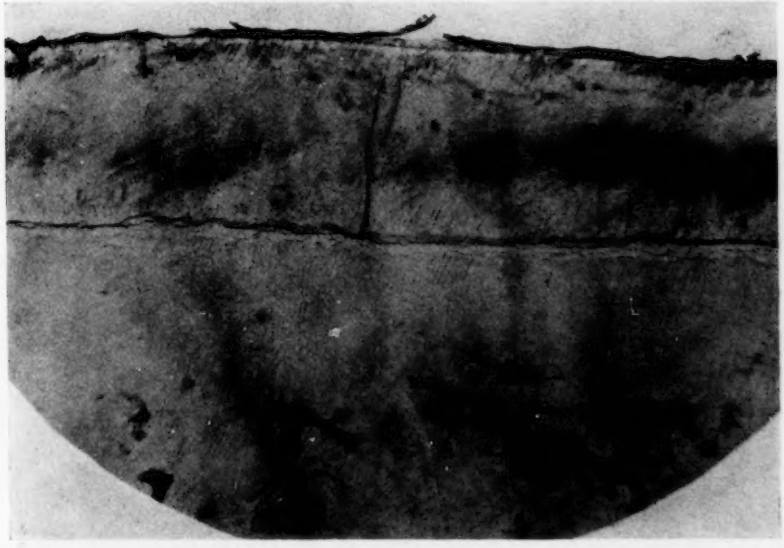

FIG. 5. Labio-lingual section upper central incisor. The enamel cuticle is stained with gentian violet and the ends of segments are raised from the enamel. Interglobular spaces show in dentin. (Prepared by grinding. × 60.)

and eventually complete dissolution of the parts. Miller was an American dental investigator who received extensive training in the German medical schools and was under the influence of Koch during the former's investigation of the etiology of caries. Since the report of his work, in 1889, no evidence has been adduced to successfully controvert the hypothesis. On the other hand, until recently very little additional data have been secured on the bacteriology of dental

caries, though the science of bacteriology has had its phenomenal development since his time.

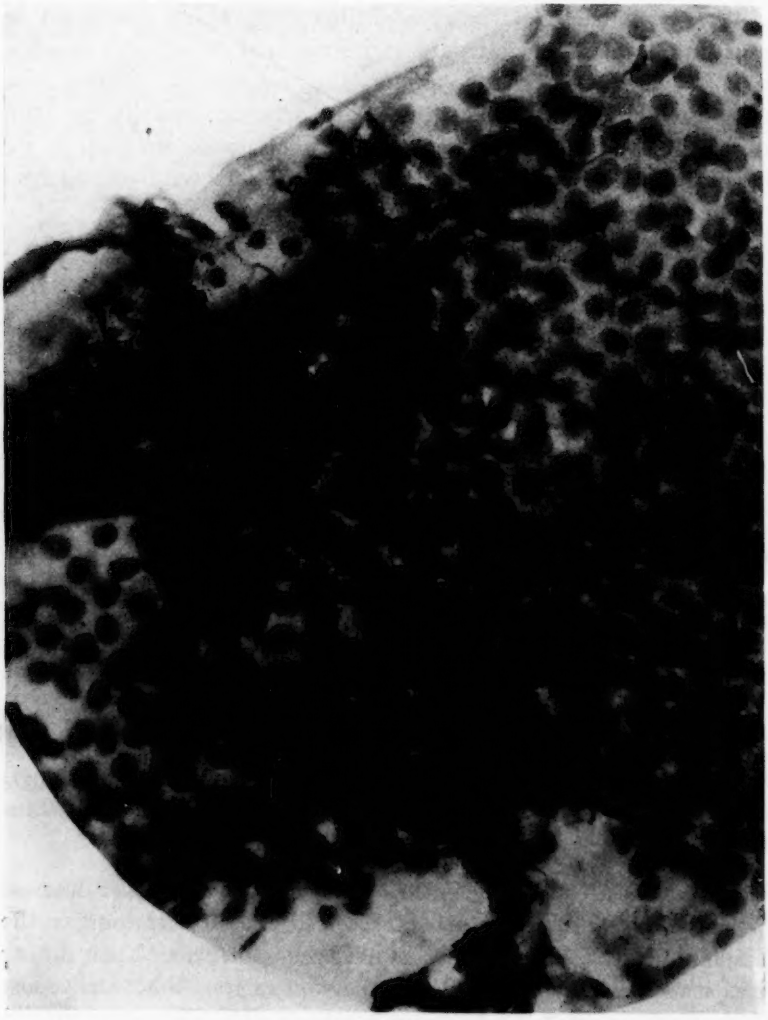

FIG. 6. Enamel cuticle floated from a newly erupted tooth. Clear layer, shown at edge, is superimposed with cells. (Stained with haematoxylin and eosin. × about 500.)

The most recent work in dental bacteriology seems to indicate a small group, or possibly one specific organism, as causative of dental caries. These organisms have a constant habitat about the hard dental tissues undergoing caries. Captain F. E. Rodriguez, D. C.,

FIG. 7. Enamel cuticle floated from a tooth of an elderly person. The oval bodies are areas where one layer of the membrane has shriveled. (Stained with haematoxylin and eosin. × about 500.)

Army Medical School (12), during the investigation of this subject, repeatedly recovered and cultivated these highly aciduric bacteria both from the surface and depth of the hard tissues. He also produced caries-like lesions in vitro with pure cultures of these organisms,

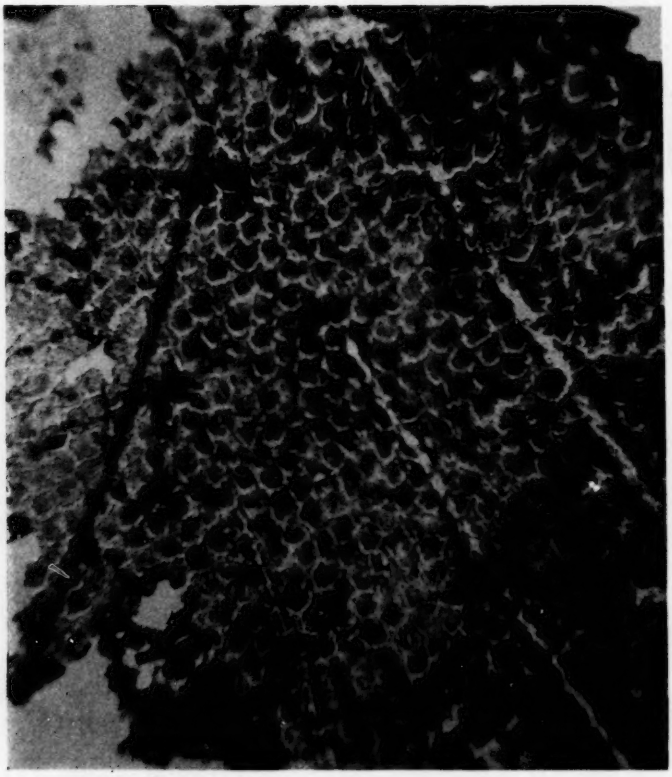

FIG. 8. Enamel cuticle, showing surface which has been in contact with ends of enamel rods. Roughly hexagonal figures are impressions of the free ends of the rods. (Stained with haematoxylin. High power.)

both at the maximum acidity of the cultures of about pH 3 acid concentration and in buffered cultures of a reaction of pH 6.9 to 7.2. British investigators (8) previously reported similar results, and more recently Professor Bunting of the University of Michigan conducted extensive work along similar lines. The proof that a specific bac-

terial agent is the etiologic factor in dental caries may be near at hand. Extension and confirmation of the work already reported are desirable.

Hypoplastic disturbances of the teeth of experimental animals have been produced by subjecting them to deficient diets during the genetic period, but a sub-normal dental structure is not caries. Dental caries is not directly dependent upon metabolism; it may or may not develop in defective dental tissue, depending upon whether the exciting cause was present over a sufficient period. The pathological process known as dental caries is bacterial in character; it is initiated on the periphery and develops pulpward.

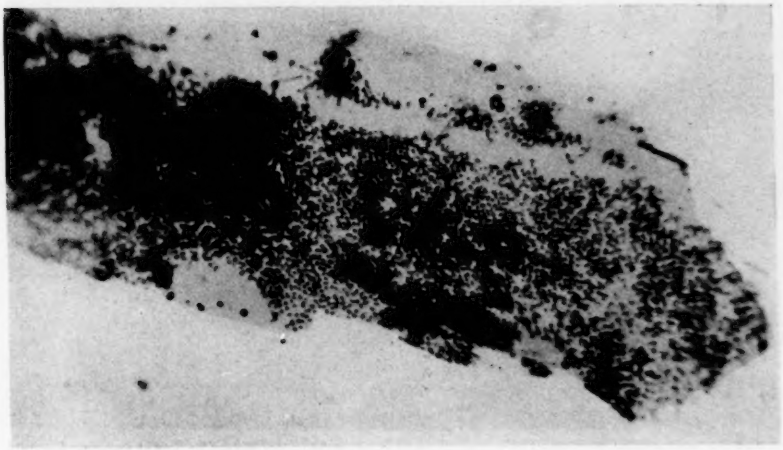

FIG. 9. Enamel cuticle floated from tooth with surface microörganisms in situ, mostly very short bacilli. (Gram's stain. High power.)

(*b*). *The predisposing causes*

The predisposing causes of any disease may be greatly amplified; and there is always the danger of confusing susceptibility and contributing factors to a disease with the specific exciting cause, if the latter is not positively known. It is a recognized factor of pathology that disposition to disease may be congenital and find expression through obvious structural abnormalities or through subtle functional defects (2). Developmental defects in the teeth, even though

they occur after birth, are in this category. It is permissible to assume that the distribution of the exciting cause of caries is universal in the mouths of modern civilized peoples, for it is difficult to find an individual in civilized communities who has no evidence of dental caries, but the extent of the morbid process has greatly varied in different mouths. From a study of the localization of the lesion, the influence that structural defects have on the initiation and prog-

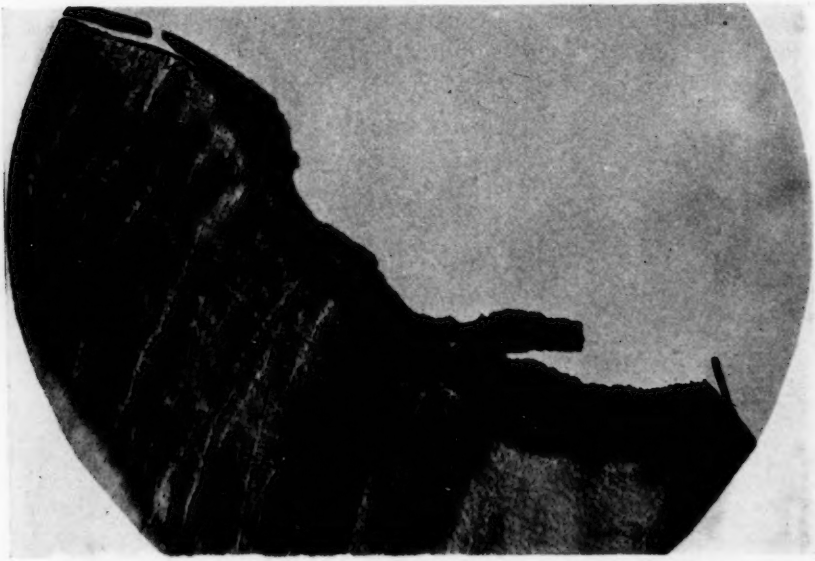

FIG. 10. Ground section of molar, showing shallow pit with enamel cuticle in situ. Very early caries in connection with the cuticle is shown. On either side of the depression the cuticle is normal; and in the pit it appears thicker due to surface bacteria and imbibition of fluid. Subjacent to the thickened cuticle, the enamel has been partially decalcified.

ress of the process is patent. The dietaries of different people have a high correlation with the incidence of caries. Function is an important factor in the development of the maxillae and teeth, and their continued preservation is partly dependent upon function.

There are evidences of lack of structural integrity of the teeth of the white race, such as the common occurrence of deep faults in the enamel. Suppression of the third molars is frequent, their eruption

in malposition is common, and aberrant morphology is almost the rule in contrast with a more normal type found in primitive people. This condition may be a compensatory degradation with the shortened maxillae and high facial angle of the white race. The upper lateral incisor exhibits a high incidence of aberrant morphology and an almost constant developmental fault on the lingual aspect. This lingual surface defect constantly determines localization of the caries

FIG. 11. Ground section of enamel of molar, showing microbiotic blanket on periphery and greatly decalcified subjacent enamel. A differentiated pericolumnar structure contrasts with rods and intercolumnar interstices. (Stained with gentian violet. × about 1000.)

process. Dental operative technique very often fails in inhibiting caries in this location.

What the epidermis is to the body as a whole, the enamel is to the tooth. The enamel is both analogous and homologous to the epidermis. As the cuticle affords for the deeper structures a protection from destructive invading microörganisms and other destructive agencies, so the enamel, generally speaking, affords protection to the subjacent dental tissues As the superficial layers of the epidermis are dead and do not react to infection, so the enamel is an inert,

non-reacting tissue. As the epidermis possesses various histologic atria permitting the passage of bacteria to the dermis, such as hair follicles, sebaceous follicles, perspiration ducts, so the enamel presents infection-atria in the form of deep faults from incomplete fusion of lobes produced by different amelification centres. In the skin these atria are normal histological structures; but infection-atria in the enamel are usually structural faults. The extent and location of these defects parallels the intricacy of the morphology of the teeth.

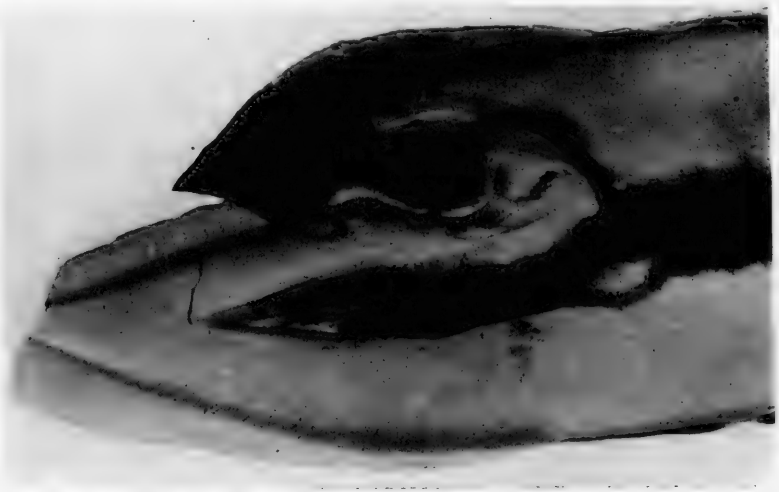

FIG. 12. Ground section of upper lateral incisor, showing a gold filling in outer part of carious lingual pit. Progress of caries was not appreciably interfered with by the filling. Flask-like carious cavity subjacent to filling with adventitious dentin intervening between it and pulp. (× 10.)

Teeth of simple morphology usually possess no developmental faults and concomitantly enjoy a high resistance to caries (5). The presence and extent of developmental dystrophies are determined by infectious diseases and disturbed metabolism during the formative period of the teeth; but neither discontinuance of infection, improvement in metabolism, nor change of diet can affect the intrinsic structure of erupted adult enamel. If strings of organic material were present, either in compact normal enamel, which apparently is not the case, or in loosely constructed hypoplastic enamel, vulnerable

atria for the penetration of caries-producing organisms would be afforded. Most teeth present some loosely constructed or incompletely developed areas which are often quickly affected by caries, but the localization and penetration of the caries process is not entirely dependent upon such a condition.

FIG. 13. Carious dentin from tooth cervix, showing heavy infection of dentinal tubuli. (Ground section. Gram's stain. × about 1000).

III. LOCALIZATION AND PERIODICITY OF CARIES

The bacteria constantly associated with caries are widely distributed in the mouth. Dental caries is strictly a localized process; its occurrence is usually bilaterally symmetrical. This symmetry points to internal as well as external factors in the process. Intrinsic characteristics of individual teeth help to determine the localization

of the process. The occurrence of caries in the individual teeth and their various surfaces differs widely. The mandibular anterior eight teeth as well as the maxillary cuspids enjoy a high degree of freedom from caries. On the other extreme the mandibular first molar is affected by far the most often (5). A conservative estimate, based

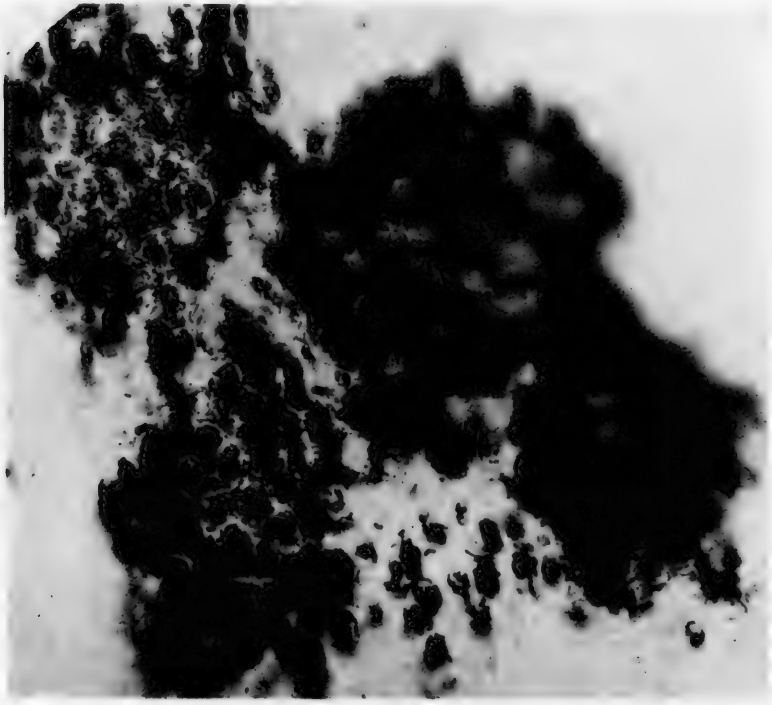

FIG. 14. Infected, carious, dentin. The dentinal tubuli are cut in cross-section. Non-infected tubuli are not stained. (Gram's stain. × about 1000.)

on the compilation of considerable data, of the incidence of caries in this tooth is 70 per cent. In a group of males aged eighteen, who probably were above the average physically, the incidence of complete loss of this tooth was 18 per cent. The occurrence of loss of the maxillary first molar was 7.5 per cent. The ratio of loss of the former to that of the latter is 2.4. Observed factors which

aid in causing this considerable difference are: (a) Somewhat earlier eruption of the mandibular molar, and (b) a larger and more complicated arrangement of its occlusal surface. There is a greater lineal presentation of fissures. The vulnerable buccal pit materially

FIG. 15. Granulation tissue, chronic proliferating periodontitis, about apex of pulpless tooth. (H. and E. stain. Low power.)

increases the occurrence. (c) Gravity and the occlusal force of the mesio-lingual cusp of the maxillary first molar drive food debris into the upright groove or V-shaped sulcus. The tooth is at the lowest point in the occlusal curve. Conversely, the maxillary first molar

presents its morsal surface at the lowest point of the complementary convex curve of the upper teeth. Gravity and the inverted V-shaped sulci of maxillary molars tend to free them of debris. (d) The

FIG. 16. High power view of a portion of the granulation tissue in Fig. 15, showing various types of adventitial cells; many plasma cells are evident.

orifice of Stenson's duct being near the maxillary first molar greatly aids in freeing it of food debris. (e) Lingual friction is much greater

on the occlusal surface of the upper, which is facilitated by its position. The localization of caries is apparently determined by anatomical relationship, function, morphology, histology, including surface

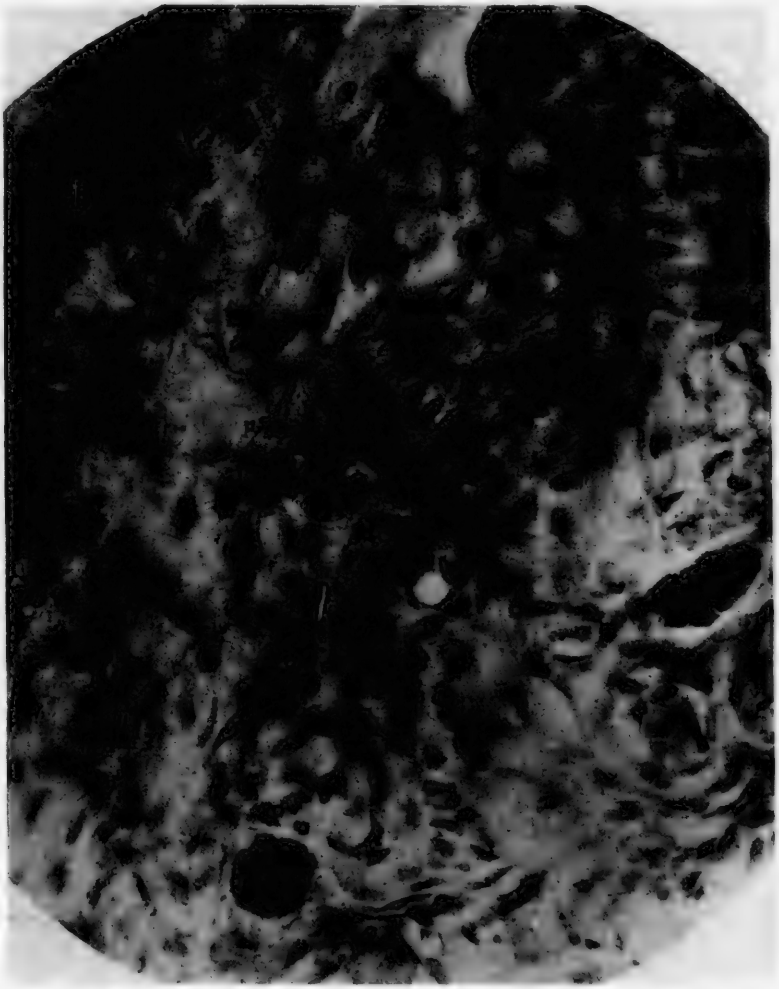

FIG. 17. Section of normal periodontal membrane, showing three epithelial rests. (Stained with haematoxylin and eosin. × about 550.)

detail and developmental dystrophies. There is a strong correlation between incidence of caries and intricacy of morphology of the teeth with which is constantly associated structural faults.

Clinical observation and statistical data agree that the process localizes in three typical areas: (a) At the bottom of pits and sulci; (b) on smooth proximate enamel surfaces; and (c) about the cervices. Histological study of these three areas, shows, among other things, that, (a) about the bottom of many sulci and pits, there are deep structural faults sometimes leading into the subjacent dentin. There is often a hypoplasia or other form of developmental dystrophy of the tissue in the area. (b) The enamel on the proximal surfaces of the teeth is usually the most perfect of that in any location, but there is sooner or later a slight facet worn on this surface as a result of functional movement of individual teeth, and that this area is least exposed to natural or artificial cleansing. (c) At the cervices of many teeth, especially in persons passed middle life, there is an area of denuded cementum or dentin due to recession of gums. In a considerable number of teeth there is a congenital absence of enamel or cementum over a band at the cervix.

Loosely constructed enamel succumbs to the process of decalcification more rapidly than well-formed enamel, while pits and fissures form natural retention centers for food debris. Well-formed enamel protected by its cuticle offers considerable resistance to the inroads of caries, and frequently a state of arrested caries is noted on the proximal surfaces. Because of the facet worn on the proximal surface, the enamel is deprived of its cuticle, which is highly resistant to acids. Under abraided edges of the cuticle bacterial colonization is insured protection. Unprotected enamel cannot cope so successfully with a deleterious environment as enamel covered by the cuticle. Denuded areas at the tooth cervix have a high liability to caries. Dentinal tubuli or the penetrating canals in the cementum are both readily invaded by microörganisms. The peaks of occurrence of caries in these three tissue areas occur at different ages of the individual.

Periodicity in the occurrence of dental caries is well-marked. The periods of high incidence cover fairly long periods and are ordinarily separated by a long period of decreased incidence. Irregular periods in connection with some systemic disease are sometimes interpolated.

The first period of high initiation is childhood and adolescence. Early and continuously in this period caries is prone to localize in pits and fissures. Caries in these locations penetrates pulpward and usually progresses fairly rapidly. The incidence of caries in childhood and adolescence is the highest of any period. Teeth having developmental faults readily succumb soon after eruption through the gums and exposure to the deleterious environment. Teeth not decaying during this period are teeth of better structure and resistance to the deleterious oral environment of youth. The vulnerable succumb early, those of greater integrity persist. There is much evidence that this is the basis of the difference in incidence in adolescence and maturity. Besides this predisposing condition to disease inherent in the tissue, there are, of course, changes in environment and physiology of the teeth as maturity is reached which undoubtedly help to decrease caries. A more varied diet, increased mastication, greater development and function of salivary glands, more active use of lingual and buccal musculature, and possibly stricter oral hygiene, may all aid in protecting the teeth.

At early maturity the condition of the dental tissues is more stabilized, and the tendency to decay markedly decreases. Further damage may be done by extension of the lesions by continuity, but initiation of new carious areas is not so common. By penetration and surface extension cavities on proximal surfaces will become manifest, though the lesions may have begun years previously. With the advent of advanced years there is an increase in the frequency and progress of caries. The preponderance of caries during this period is located at the cervices of the teeth. This condition has been referred to as senile decay. The necks of the teeth are often bare as a result of the recession of the gums. Many teeth which show no caries of the crown succumb to caries of the dentin at the neck. Besides the high liability of exposed dentin to infection, there is considerably less cellular reaction on the part of the tissue in old age, although cellular resistance by the dentin to invasion is not of so much importance, as dental caries will eventually destroy even teeth manifesting a pronounced protective reaction. The necks of the teeth in the aged are notoriously unclean. The cervico-proximal surface is the usual site of caries in primitive people (6). The

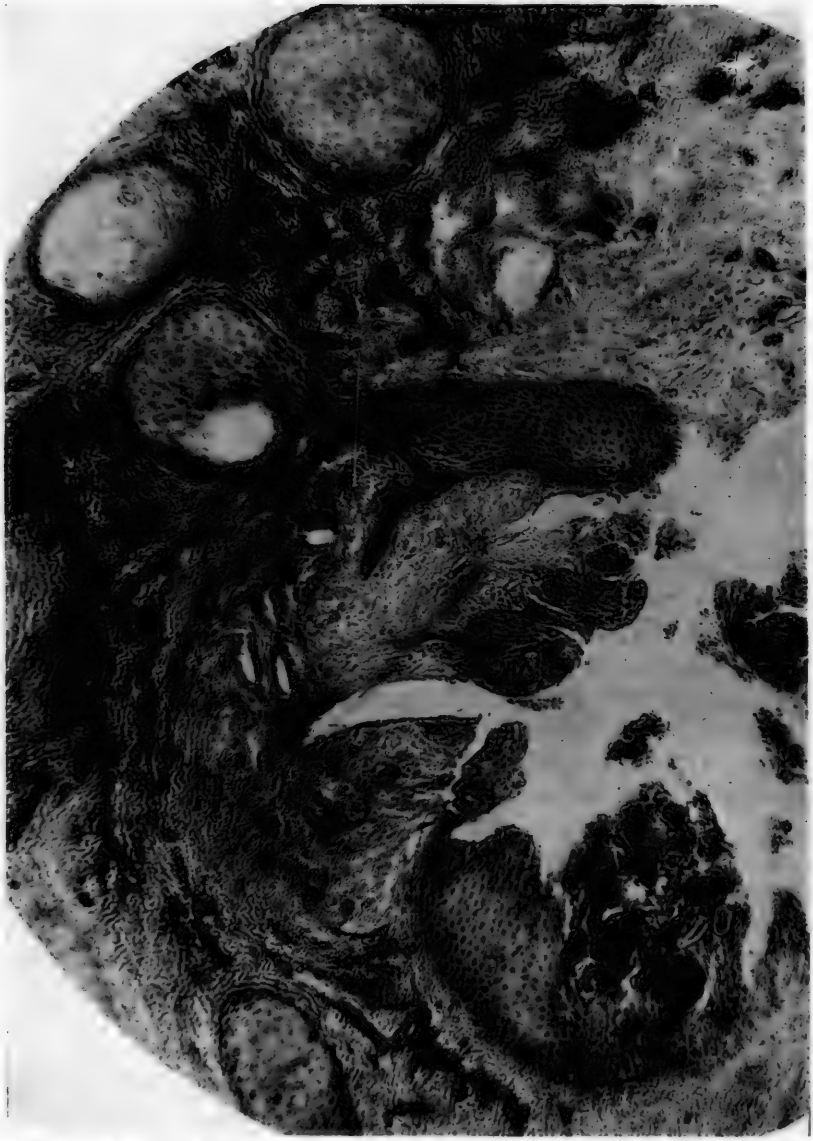

FIG. 18. One end of radicular dental cyst, showing epithelial lining from which many cells have desquamated. In the connective tissue wall are several globular masses of epithelium, one of which shows beginning cystic degeneration. Old organized hemorrhage in wall. (H. and E. stain. High power.)

character of the tissue, abetted by the environment, determines the localization of the lesion.

Other periods of susceptibility to caries which are not so clearly defined are often mentioned. Pregnancy is such a period. Many women have caries at the time they become pregnant. If there is an actual increase in new lesions in the enamel during this period, it must be due to changed conditions of the oral environment of the exposed surfaces of the teeth. Owing to physiological urge, change of diet during pregnancy is common. Regurgitation of highly acid stomach contents occurs. These factors would influence the oral environment, with resulting change in the flora that may induce caries. There is need for reliable statistics on the occurrence of caries during pregnancy.

IV. PATHOLOGY OF DENTAL CARIES

Dental caries is not analogous to caries of bone; it is essentially an infection of the hard dental tissues involving a decalcification of the inorganic matter, a proteolysis of the organic content, with consequent dissolution and destruction of the whole. The bacteriochemical process, particularly with regard to enamel, is aided by physical forces of mastication. Caries is a pathological condition peculiar to the hard tissues. The process is comparatively slow. The enamel is entirely inert and passive. There is no evidence to show any form of tissue reaction on its part against the onslaught of caries. Likewise normal cementum exposed to the process is entirely inert, since there are no cells normally in this tissue to react.

Complete knowledge of the character of the initial lesion is most important for it is on the periphery that prophylaxis against dental sepsis should logically be applied. Further information on the very initiation of the process might aid in clarifying the etiology. These facts have led us to concentrate our efforts largely on the study of the periphery of both normal and pathological enamel. The various pathological phenomena in the deeper layers have been described so clearly, by those three masters, Miller, Williams, and Black, that little more in that direction is necessary.

In the tooth crypt, before eruption through the gums, the enamel

is closely covered by the transformed remnant of its genetic organ. The epithelium of the enamel organ upon completion of its function undergoes keratinization. This epithelial remnant is most closely adapted to all surface irregularities and is invaginated in every pit and fissure. The presence of a double layer of this cuticle, in the fissures between the different lobes of the teeth, appears in many instances, to have prevented fusion of these units, which are the products of different centers of amelification. I have not seen this

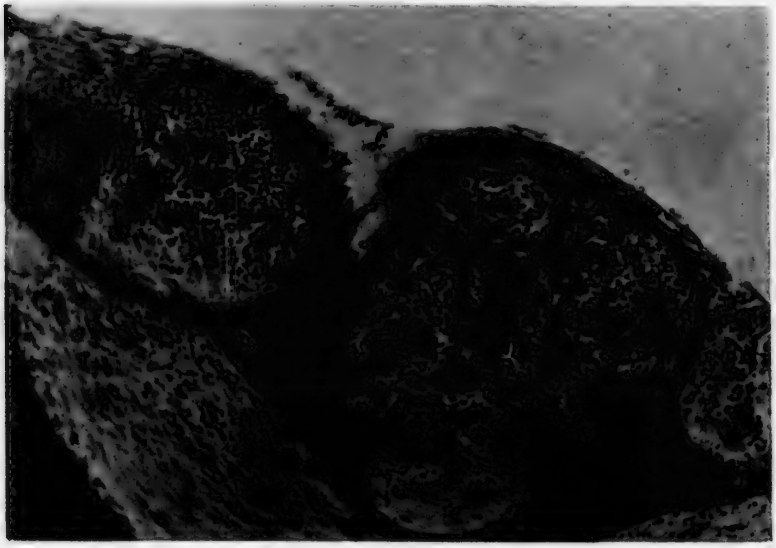

FIG. 19. Section of wall of radicular dental cyst lined with epithelium in which there are large areas of adventitial cells indicating infection. Surrounding wall of fine connective tissue. (H. and E. stain. High power.)

idea advanced in the literature, but from a study of many sections it seems altogether probable that the genetic organ got in its own way and thus produced deep pits and grooves. The enamel cuticle exists not only on the crowns of all newly erupted teeth but also on surfaces unaffected by attrition, abrasion, and chemical agents, and it may remain throughout life.

The enamel cuticle, or Nasmyth's membrane, consists of two layers: (a) a homogeneous translucent pellicle next to the free ends

of the enamel rods, and (b) one or more layers of altered epithelial cells on the free surface. In some instances, through excessive change, no epithelial elements may be discernible, or the morphology of the cellular elements may vary considerably. The whole cuticle is translucent and, therefore, macroscopically invisible. It is quite resistant to both acids and alkalies, and, where present, affords in this regard a strong protection to the chemically sensitive enamel against injury from acid. Miller noted a somewhat stubborn resistance on the periphery of the tooth to a beginning decalcification and attributed the resistance to acids to a supposed thin, dense, cortical layer of enamel. Bunting more recently has advanced a similar idea. Prophylactically this is an exceedingly important matter, as it would indicate that the natural surfaces of teeth would be injured by any form of mechanical interference. Hopewell-Smith is unable to grant a differentiation of an outer layer of enamel, considering the manner of its formation. I concur with him, and furthermore have many sections which indicate that resistance to acids and stains is entirely accounted for by the presence of the enamel cuticle.

Sections show, where there has been no break in the continuity of the cuticle over a considerable area, the enamel is not attacked. The non-susceptible area normally covered by the free gingivae is always covered with a continuous segment of the cuticle. The many physical, chemical, and mechanical vicissitudes to which crowns of the teeth are subjected naturally disrupt the continuity of the cuticle, and breaches afford entrances to the enamel surface. The free surface of the cuticle also presents an excellent matrix for the localization of the oral flora. Attrition on the occlusal surfaces removes this covering from the greater portion. A careful examination of the initial lesion both on occlusal and approximal surfaces shows the process to have begun under the very margin of the segments remaining in situ. In pit and groove cavities this obtains. What is more generally known to the profession, the initial lesion on approximal surfaces is at the margin of the facet worn by the individual physiological movement of the teeth in the arch. In beginning caries the cuticle becomes greatly thickened apparently by a heavy microbic collection on the exterior, a smaller invasion under it, and by imbibition of fluids by the cuticle. As calcium salts are washed away, the

cuticle with adherent bacteria sinks into the depression. Bits of the disintegrated cuticle may persist on the carious surface for some time. A critical examination of many of those most excellent illustrations published by Williams in 1897 and 1898, and comparison with my sections, indicate that the substratum of the bacterial plaques described by him is the enamel cuticle.

The localization of bacteria, however, is not dependent upon the cuticle acting as a nidus. Lodgment is readily afforded not only by the grosser irregularities but particularly by the microscopic roughness produced by the outcrop of rows of enamel rods. In areas subjected to attrition or brushing these plaques are largely removed, as is evidenced by the non-susceptibility of areas of attrition to caries; but in areas not subjected to attrition or brushing, bacterial zoöglea constantly remain adherent to the unprotected enamel, and caries may spread farther than in areas covered with the cuticle. There is evidence that the difference between cases of clinically dirty teeth which are not succumbing to caries, and cases of fairly clean teeth which are succumbing to caries is partially dependent upon the presence or absence of the cuticle. I have recovered the cuticle from many non-carious but superficially badly stained teeth. However, the important factor of the possible presence or absence of the bacterial exciting cause must not be disregarded.

The enamel, with its supporting dentin, is physically strong, highly inorganic but very sensitive to acid reaction. The initial lesion of the enamel subjacent to the bacterial plaque consists of decalcification of the intercolumnar substance producing innumerable interstices between the rods. The cross striae of the individual rods are next attacked. In some sections of carious enamel there is plainly visible an outer layer bounding each rod, possibly a somewhat different material than the body of the rod or the intercolumnar material. This is not seen in normal enamel and is a new observation in carious enamel, but it may be an optical effect. The partially decalcified enamel contrasts sharply with normal enamel. The appearance of carious enamel simulates very closely partially decalcified enamel produced by the application of acids in the laboratory. Carious enamel, however, has considerable pigment in the interstices which does not appear in decalcified enamel. This similarity and the dif-

FIG. 20. Section of radicular dental cyst, showing epithelial proliferation; long narrow spaces have probably been occupied with cholesterin crystals. (Stained with H. and E. × 100.)

ference are plainly shown in sections of teeth affected in these two ways. Bacteria do not penetrate far into the interstices but adhere to the surface. This lack of penetration of bacteria into the interstices is true of direct caries in well developed enamel. The conditions in these spaces apparently are altogether unfavorable chemically for bacterial growth. In hypoplastic enamel, in backward caries of enamel from the dentinal surface, and in fracture lines, bacteria may be found.

The entire thickness of the enamel, as well as a considerable depth of the dentin, may be partially decalcified without any appreciable break in the periphery of the enamel. This porous form, in which there are many interstices, may hold for some time the natural contour of the tooth; but through continued decalcification, aided by physical forces, the surface is broken down until that most highly susceptible area at the amelo-dentinal junction is reached, where the process rapidly and extensively spreads in a lateral direction, undermining what may have been previously sound enamel. Sections of teeth stained in bulk with silver nitrate show penetration of the affected enamel in sharp contrast to the unstained normal tissue. Thus an extensive and deep partial destruction of the hard parts may exist without the knowledge of either dentist or patient.

Exposed dentin is readily infected. The exposure is brought about through carious destruction of the protective enamel; through recession of the gingivae at the tooth cervix, where in many cases there is a congenital absence of enamel or cementum over a strip of dentin; and through developmental dystrophies at the bottom of deep fissures. The protoplasmic content of the dentinal tubuli affords an ideal habitat for many species of bacteria. Both in the granular layer at the junction, and in the parallel rows of intergobular spaces which are somewhat deeper, there is rapid and wide-spread lateral extension of the lesion, owing to the increased organic content in these areas. The process also penetrates rapidly pulpward, following the curvature of the tubuli. The bacteria in the dentin are found within the tubuli until nearly the end of the process, when liquefaction foci develop. Miller stated that the bacterial invasion of the dentin was always preceded by decalcification; but there is much evidence that facultatively anaerobic organisms invade the tubuli before

decalcification of the area. Especially when subjective symptoms appear there is high probability of hopeless involvement of the pulp by infection.

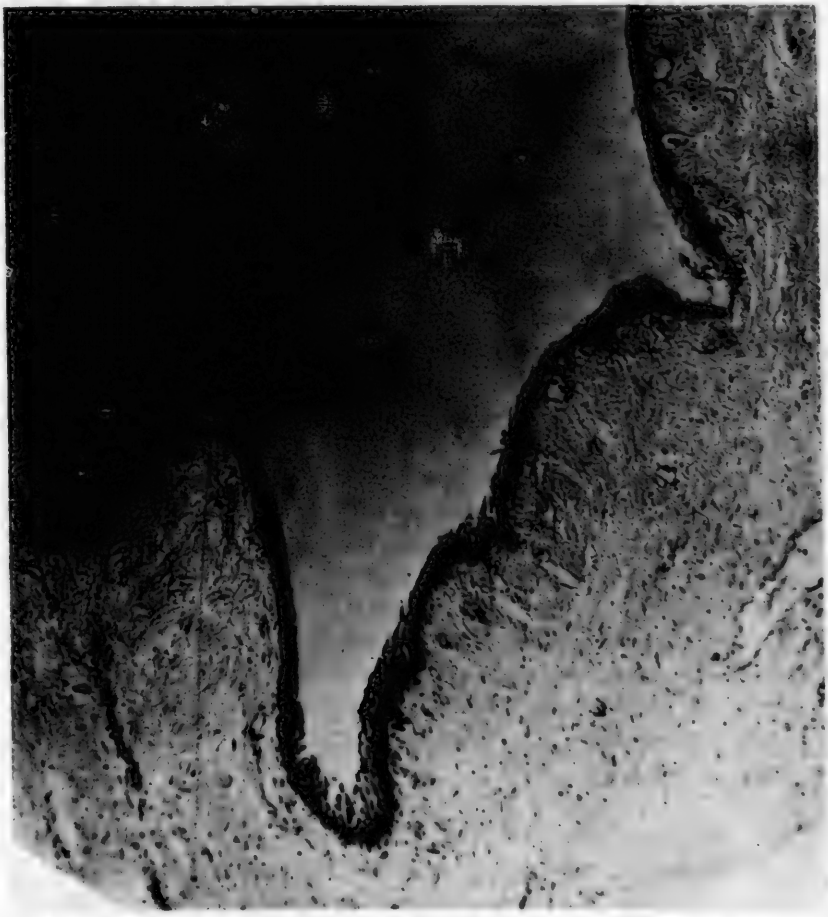

FIG. 21. One end of a radicular dental cyst. (Preparation and amplification similar to Fig. 20.)

There is some reaction to this invasion from its very initiation at the outer boundary of the dentin. The protective reaction is manifest by a translucent zone that follows the course of the tubuli and

intercedes between the lesion and pulp. The appearance of translucency is produced by a reduction of the lumina of the tubuli through a deposit of inorganic material. This tissue change is limited to the fibrils irritated. This same phenomenon is present subjacent to lesions of attrition and erosion. This translucent zone is somewhat analogous to sclerosis of bone. It is consequent upon pulpal reaction to the irritating process, and is produced in connection with the fibrils, which are prolongations of the peripheral pulpal cells. If progress is not unusually rapid, secondary dentin as well as various forms of adventitious dentin will be laid down on the walls of the pulp chamber as a means of self protection on the part of the pulp. These later dentinal formations are quite as susceptible to the invading process as primary dentin. Consequently, these vital reactions on the part of pulpal cells manifested in connection with their dentinal offshoots, while slowing up the progress of caries, are eventually futile. Ultimately, liquefaction of the dentin exposes the pulp, but bacteria reach the pulp some time previously.

Thus the morbid process known as dental caries is characterized by localization of heavy bacterial masses on the periphery of the enamel. Decalcification of the enamel is produced subjacent to some of these bacterial collections. The destruction of the enamel is brought about by a combination of bacterial action and physical forces. The destruction of the dentin is effected by a combination of decalcification by acids and proteolysis of the extensive organic content. Dental caries always proceeds from the periphery pulpward, and in the absence of the exciting cause, bacteria, it cannot occur, irrespective of diet, disturbed metabolism, or the presence of developmental hypoplasia.

V. SEQUELAE OF DENTAL CARIES

In continuance of caries of the hard parts there is infection, inflammation, and usually early necrosis, of the dental pulp. Although the pulpal cells often manifest a stubborn resistance, the reactions varying from the deposition of adventitious dentines and fibrosis to gross lacunar resorption, the efforts are futile. The anatomical position of the pulp within non-yielding walls rigorously limits its reactions; and peculiar histological characters, such as lack of col-

lateral circulation and valveless veins, doom it to early death. The laying down of adventitious dentines gradually diminishes its size. Reduction of the apical foramen by cemental hyperplasia decreases the blood supply. Both of these reactions to irritation in the course of caries, while primarily protective in character, add to the pulpal difficulties in overcoming infection. With the death of the pulp, the nutrition of the dentin is entirely cut off. The pulp is a soft, vascular tissue, easily influenced, and unable to recover from inflammation due to trauma or infection. If overwhelming infection with acute inflammation does not produce rapid necrosis, chronic inflammation eventuates in obliteration and replacement.

An immediate result of fulminant infection of the pulp is infection by way of the root foramina of the apical alveolo-dental periosteum with consequent inflammation, often terminating in acute or chronic alveolo-dental abscess, in which there is gross pus with periodic evacuation through a fistula. The infection extends by continuity and often produces a limited rarefying osteitis. In a few cases of low resistance or high virulence of the infective agent there may be a rapid diffuse osteomyelitis. Empyema antri is another result, which sometimes follows infection of the maxillary premolars and first molar. Chronic periapical infection usually follows less fulminant pulpal infection, unless there is early pulp extirpation under aseptic conditions. The ordinary characteristic tissue change is a low-grade chronic proliferative inflammatory reaction—a productive periodontitis. The periodontal membrane progressively thickens; a sheath of "principal" fibers adjoining the alveolus is displaced from the remainder of the membrane to form an enveloping capsule about the inflammatory process. A layer of fibers connected to the cementum may persist for some time. Fibroblasts form new connective tissue, bundles of which form trabeculae running from the capsule into the interior of the mass. Between these trabeculae is a looser granulation tissue. The mass is well vascularized and heavily infiltrated with wandering cells: leucocytes, lymphocytes, plasma cells, and macrophages. The plasma cell is much in evidence. Minute pus foci may be present. This low-grade granulation tissue persists as long as the causative factors operate. Streptococcus viridans has been recovered most frequently from this tissue, but

various other organisms may also act as excitants. The alveolar wall becomes resorbed, and eventually the cementum or even dentin is resorbed by the action of foreign-body giant cells, phagocytes, or by lysis. In cases of low virulence of the infection, high resistance of the tissues, or other determining factors, a reaction may occur resulting in cemental hyperplasia, a dense fibrous capsule, and a small area of condensng osteitis, all indicative of a successful limitation of the infective process.

FIG. 22.

FIG. 23.

FIG. 22. Radiogram showing resected lower lateral incisor. See figs. 22–27.

FIG. 23. Photograph of resected end of incisor (fig. 22), with adherent soft tissue, after extraction. (× 10.)

In the normal periodontal membrane there are strands or aggregations of epithelial cells located fairly close to the cementum. These cells are epithelial rests originating from the tooth anlage. Their presence is so constant that it must be considered normal. The reader is referred to Melassez's (9) classical study of these epithelial rests, to which he refers as *les débris épithéliaux*.

Infection of the periodontal membrane may cause proliferation of the epithelial rests, for it is very common to find considerable epithelium in the chronic periapical processes. Sometimes heavy trabeculae of epithelium pervade the mass of new connective tissue, the areas between the epithelial strands being heavily invaded by various round cells. Many leucocytes immigrate into the epithelium, particularly in areas which are degenerating. Since blood vessels do

not enter them, epithelial masses are dependent upon the lymph spaces for nutrition. By proliferation from the basement membrane considerable masses accumulate until those cells farthest from the source of nourishment degenerate. Normally on an epithelial surface desquamation occurs; in these compact masses this cannot obtain, but central degeneration and liquefaction occur. This is the usual origin of the frequently occurring pathological condition of so much interest known as radicular dental cyst. The typical radicular cyst contains some viscid fluid and crystals of cholesterol, and the epithelium lining the cavity varies from very thick masses to but a single layer. We have sections of a case in which a cavity is lined with a single layer of columnar ciliated epithelium, the source of which may be the mucous lining of the maxillary sinus. The cyst may become infected, with abscess formation.

In the sections of pathological periapical tissues I have examined, epithelium occurs more frequently than the older descriptions would lead one to expect. The radicular dental cysts of small size may or may not be diagnosed radiographically. The radicular cyst is a well defined type, with the distinct cellular character described, and should not be confounded with the pericoronary, or so-called dentigerous, cyst, the character and etiology of which are entirely different.

The operation of apicoectomy is frequently resorted to in certain cases of periapical infection. Radiographic post-operative examination of these cases seems to indicate a considerable regeneration of bone in many cases where, we assume, infection has been eliminated. The actual tissue condition cannot be revealed by the radiogram. The histology of the relations between the regenerated tissue and the resected root-end presents an important and interesting study. The following observations were made in such a case, which had been clinically considered a success. It probably is fairly typical.

Case history: Female, age 30. Lower left lateral incisor resected in January, 1919. Radiographed August 5, 1924. A comparatively small radiolucent area showed next to the root. For prosthetic reasons the tooth was extracted the same day.

A small bit of soft tissue covering the lingual two-thirds of the cut surface remains adherent upon extraction. Upon section of the hard and soft

tissues in juxtaposition, it was observed that the soft tissue is made up of connective tissue resembling in all essential respects the periodontal membrane, with which it is continuous on the lateral surfaces of the tooth. It undoubtedly is the product of proliferation from fibroblasts of the periodontal membrane. In that part of the tissue next to the cut end there is a considerable infiltration of wandering cells: leucocytes, lymphocytes, plasma cells, macrophages, and some multinucleated giant cells; this reaction is usually found in the presence of dead tissue or a foreign body. At the angles, including both cementum and dentin there are large resorption foveolae. In some sections the resorption extended somewhat on the lateral aspect of the cementum. Over the smoother areas of the dentin, resorption was not so marked, yet in some sections it is continuous across the tooth. The root canal is partially filled with chloropercha. At the exposed end of the canal there is an exuberant mass of infiltrated connective tissue dipping for a considerable distance down in the canal; this ingrowth was made possible in all probability by displacement of successive portions of a loose canal filling or phagocytosis of particles of the foreign material.

In the resorption areas in the hard tissues, the type of phagocyte most frequently observed in apposition to the dentin and cementum is a fairly large mononuclear cell with rounded or irregular nucleus; these cells are spoken of as macrophages. There is no apparent connection between the soft tissue and the resected root. In some places there is a close adaptation of compact connective tissue to the dentin, in other places there is an infiltration of round cells adjacent to semilunar-shaped areas in which resorption of the hard parts has taken place. The cementum and dentin being inert, dense and non-vital, there could be nothing other than a loose encapsulation under the most favorable circumstances. Whether appreciable resorption takes place at some time or other in all cases, we are unprepared to state; but the amount and rapidity would vary markedly in different cases, in part depending upon infection and the presence of irritating foreign material. In this case it would appear that chloropercha in the canal is less compatible with the quiescence of the surrounding tissue than the non-vital dentin. Whether this fact is due to an innate irritating character, or the manner in which it is inserted in the canal is not entirely clear. Apparently the operation of epicoectomy should be preceded by filling the canal with a non-irritating dense material, a metal would probably prove most

compatible with the apposing tissues; and the resected end should present a well-rounded, smooth, uninfected surface. Lyons recommends silver-reduction treatment of the resected surface.

Other sequelae of dental caries such as the loss of teeth, which mutilates the arches and in the course of time induces functional and structural changes in the dental tissues eventuating in periodontoclasia, as well as the alluring subject of metastasis of infection from periapical foci, cannot be considered here.

VI. NATURAL METHODS OF INCREASING RESISTANCE TO CARIES

Natural factors that aid very markedly in establishing resistance to dental caries are functional relationship of the teeth in the arch, freedom of the teeth from embryological defects, and continued vigorous functioning. Normal anatomical and functional relationships of the teeth in the arch imply well developed maxillae. The jaws must be large enough to accommodate the full complement of teeth in functional symmetry. There should be normal occlusion. This ideal condition furthers the functioning of the dental mechanism. In turn, full use directly aids systemic metabolism and locally prevents both retention of food debris and fermentation. Arches of sufficient size to accommodate the full complement of teeth are determined by inheritance, health of the developing individual, nutrition, and early function. Functioning and maintenance of the deciduous series for their full period will materially aid in securing normal occlusion in the permanent series. The active use of the deciduous teeth on a diet with some resistance will increase the blood supply to the parts, with consequent physiological hypertrophy as against atrophy from disuse. Increased blood supply to the developing permanent teeth will tend to prevent developmental blemishes. If the deciduous teeth are used, they will be more apt to be free from caries and maintained until their physiological time of loss. Their presence in the arch, especiallly if their full mesio-distal width is maintained, will greatly stimulate the development of adult arches of ample proportions.

Structural defects in teeth are laid down only during the genetic period. What is accomplished then, whether normal or pathological, cannot be improved later through diet, metabolism, or any other

agency. This is true because the enamel is a completely formed tissue with the very minimum of metabolism after eruption. The structure of the tooth should present no developmental defects constituting areas of lower resistance for the initiation of the morbid process. One positive form of prophylaxis against dental caries, then, is to control or exert influence on the developing teeth during their genetic period. The formative period, during which the structure of the teeth might be affected, extends approximately from inception to adolescence. The prenatal period is not so important

FIG. 24. Section of end of resected incisor (fig. 23), showing connective tissue in apposition to cut end. Areas of resorption are evident. (Low power.)

as the first few years after birth, for the calcification of the permanent teeth occurs during the latter; but prenatal malnutrition may affect the deciduous series. Dental-tissue building materials should be seriously considered in the diet of the mother during lactation, as well as in that of the child after weaning.

Freedom from infection and exanthematous diseases in particular, and nutriment embodying the required formative materials both qualitatively and quantitatively aid in the reduction of dystrophies of the enamel. Recent data reported from the field of experimental

nutrition would appear to indicate the necessity of a constant ratio between calcium and phosphorus. The study of nutrition promises many valuable developments (7); but dystrophies of the hard dental tissues are merely predisposing causes of caries, and there is no analogy between dental caries and such diseases of metabolism as

FIG. 25. Another section of preceding, showing root canal into which an exuberant mass of connective tissue has grown. Guttapercha canal filling is partially displaced. Area of active resorption on right. (Low power.)

rickets. Dental caries is neither inherited, congenital nor is it strictly a nutritional disease. It is initiated on the periphery and extends inward, and is an infection with consequent dissolution of the hard dental tissues.

Continued function of the permanent dentition on a diet offering considerable resistance is imperative. A prominent anthropologist holds that the evidences of degeneracy in the human dentition are

due to non-use. The clinician observes a marked variation in the health of the mouth with use. Resistant articles of food necessitate considerable muscular work, with consequent attrition and self-cleansing of the opposing tooth surfaces. Mastication stimulates increased flow of saliva, and this fluid by virtue of its contained enzyme starts off digestion to advantage, and withal flushes food debris from the teeth. The increase of saliva is especially marked in the case of savory foods. The natural pleasure coming from tart and savory articles of diet has been perverted to an undue craving for sweets by children and adolescents in modern civilization. Children normally have a physiological drive for carbohydrate food; but this urge has been unduly catered to and excessively developed. Mastication involves active functioning of the lingual and buccal musculature, which also aids in hygiene and general healthful tonicity. As positive and striking evidence that attrition prevents caries, note is made of the extreme susceptibility to it of exposed dentin that is not kept clean; but exposed dentin on the incisal or occlusal aspects of the teeth, when subjected to continual attrition, does not decay. Not only is dental health maintained to a marked degree by function, but the whole body economy is benefitted. Unfortunately caries early destroys some teeth whose loss mutilates the arches, thus reducing the functional efficiency of the apparatus, greatly inhibiting natural cleansing tendencies, and producing a vicious cycle very early in the individual's life. The teeth do not function and are not self-cleansing because modern diet is pappy and denatured. Leafy vegetables, nuts, and coarse, fibrous, tart and savory articles are strongly indicated.

VII. DENTIFRICES

The physiological or therapeutic effects of dentifrices are evanescent. Their physical and chemical properties may be positively harmful, and their use may result in permanent injury to the enamel or other oral tissues. Coarse or sharp abrasives wear the enamel cuticle and enamel; acids disintegrate a superficial layer of the enamel, detach the cuticle, and by repetition continue to cause the dissolution of the protective tissues of the teeth. Abrasives other than a precipitated calcium carbonate are questionable. The harmfulness of

a dentifrice increases directly with its acid reaction. The enamel is very sensitive chemically to acids. Many preparations are widely advertised as being capable of immediately whitening the teeth. A material which will do this is positively harmful, as it is a positive indication of superficial decalcification and removal of the translucent

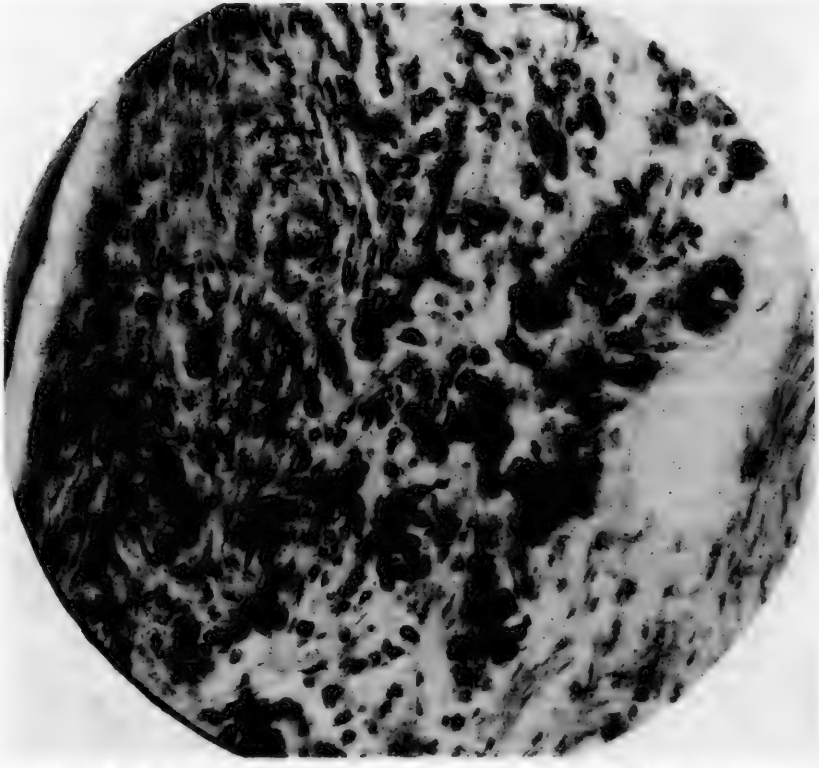

FIG. 26. High power view of preceding, showing phagocytosis of foreign material from root canal. (H. and E. stain.)

cuticle. The surface will be greatly roughened, collections of food and bacteria will adhere more readily than before its use, and the tissue will be more sensitive to further disintegration. It is absurd to postulate that, with a transient variation of the pH of the oral fluids, the propagation of deleterious organisms will be inhibited;

or that there will be anything but a very short reflexive effect on the reaction of the saliva to produce a medium inimical to the propagation of caries-producing microörganisms; or that the enzymic content will be materially altered by a labile agent. Miller proved the futility of oral antiseptics as a prophylaxis against caries thirty years ago.

A new but utterly false approach to the prevention and even cure of incipient caries, with dentifrices, is based on the false premise that the enamel is not fully calcified upon eruption and continues to incorporate calcium salts from the saliva. The corollary of this mistaken idea is that the integrity of partially decalcified enamel, that is to say, enamel which is succumbing to caries, can be reestablished by the application of the proper calcium formulae. Enamel is a tissue; its integrity cannot be enhanced nor its affected structure salvaged through the application of lime salts to its surface. Enamel is formed by and under the influence of the living genetic cells, the ameloblasts. Enamel, though it is highly calcific and possesses the least amount of organic matter of any tissue of the body, is nevertheless a formed tissue, a biological product. When the teeth erupt, the genetic cells have changed and atrophied following the completion of their function; the nutriment to them is entirely cut off; the formation, whether normal or containing developmental defects, is complete. The structure is not improved upon, either physiologically through the agency of the saliva or artifically by the application of calcium or other salts. Dental tissues cannot be synthetized by mechanical or chemical manipulation. These facts are arrived at not only by inference from analogy, since the dental tissues are no exceptions to general biological laws, but direct laboratory examination of the tissues produces the positive evidence. If adult newly erupted or non-erupted teeth are removed surgically, and subjected either to various aniline dyes or silver nitrate in gross, using uninjured teeth which have been exposed in the mouth for a long time as controls, the penetration of the dyes will be no greater in the new teeth than in the old. Where the enamel cuticle is intact there will be no penetration whatever in either class of teeth. If enamel is porous as a result of partial decalcification by acids produced by the fermentation of carbohydrates, or as a result of exposure to

laboratory reagents the interstices might be superficially filled in mechanically; but this does not restore its integrity. Partially decalcified enamel, though holding its form for a time, is eventually doomed.

Dentifrices designed as mild detergents to be used on tooth brushes probably have some value. A bland detergent dentifrice may be used to advantage as a mere adjuvant in the brushing of the teeth, in lieu of natural physiological cleansing through proper dietary and functioning of the masticatory apparatus. In artificial cleaning the aim is to remove food debris and disturb colonization of bacteria, but practically nothing more than a mechanical disruption of the bacterial zoöglea and flushing away of loose material are required. There should be no abrasives to remove the translucent pellicle or, from constant use, to produce an abrasion or erosion of the hard tissues. Examination of a large number of men in middle life who use the tooth brush reveals an alarming condition of the teeth. The cervix is often worn away through cross brushing and harsh dentifrices. Recession of the gums exposes the less dense cementum and dentin, and, by a constant misuse of the brush and harsh materials, many of the teeth are cut by grooves from one-third to one-half the diameter of the teeth. Because enamel is extremely sensitive to acid, it is safest for the agent to possess a mildly alkaline reaction. Dentifrices need not contain more than a finely precipitated calcined calcium carbonate, soap, aromatics, and the necessary vehicles.

VIII. SO-CALLED DENTAL PROPHYLAXIS

The specific etiology of dental caries not being known, there is, indeed, no true dental prophylaxis. Vigorous functioning and oral cleanliness, as practiced by the individual, aid directly as preventive measures. D. D. Smith evolved a technique for a frequent, methodical, and thorough cleansing and polishing by use of abrasives of all the exposed surfaces of the teeth. This process is the so-called dental prophylaxis. After individual brushing, this was the next artificial means attempted to prevent dental caries. It was believed that a highly polished tooth would not decay. Unfortunately in the mind of the average dental practitioner, prophylaxis has come to have a limited and synonymous meaning with tooth-surface polishing. In-

sofar as dental caries is concerned, it is probable the present training and practice of tooth-polishing by the so-called dental hygienist is largely misdirected effort. In fact it appears that the vogue of the dental prophylactic treatment is on the wane.

The application of abrasives to the tooth surfaces as popularized by Dr. Smith and his many followers has several serious counts

FIG. 27. High power view of resected root, showing area of resorption of hard tissue near dentino-cemental junction.

against it: First, it is laborious and time-consuming, consequently costly and not available to the masses, even though it were of value; it has been found that very few of even the most enthusiastic patients will continue with it long. The impracticability of the procedure

was brought to the attention of the profession by no less a dental authority than G. V. Black (1). Second, a preponderance of statistical data indicate the highest incidence of dental caries has its initiation about developmental faults; but these faults are usually of microscopic dimensions and, therefore, the principle involved cannot be applied to the most susceptible areas. The orifices of many pits and fissures will not admit the point of a new No. 14 dental explorer, yet caries may be advanced and rapidly extending laterally at the amelo-dentinal junction. Even where the faults are of macroscopic size, they are too small to admit of being polished by the agents in use. Thus the very areas which need to be fortified against the attack of the process most frequently, cannot receive the benefit of this form of treatment. Third, the application of abrasives on smooth enamel surfaces, which normally have a low liability to caries, disrupts the continuity of the enamel cuticle, and the exposed enamel is more liable to succumb to caries. Miller (11) warned against removal of the enamel cuticle by abrasives. Hopewell-Smith (3) has demonstrated the protective character of the cuticle.

IX. CHEMOTHERAPY, PROPHYLACTIC ODONTOTOMY, FILLING OF INCIPIENT CARIOUS CAVITIES

Bacteriologists may determine that a specific organism or group causes the pathological process known as dental caries. Were the specific cause known there might be developed a method of immunization. Dietetic and metabolic studies may evolve ways of preventing structural defects, and prescribe proper diet for the continued functioning of the teeth. Pending positive results from these sciences, it is desirable that an operative method be evolved which can be practised by the rank and file of the dental profession to decrease the liability of known highly susceptible areas of the teeth to the morbid process of caries. It is unfortunate that so few patients present themselves for treatment of incipient caries; and probably more lamentable that the endeavor of the profession is so largely directed toward the treatment by surgery or otherwise of the sequelae of caries and the replacement of lost dental tissue by prosthesis. A marked decrease in individual welfare and efficiency, and a tremendous economic loss in the aggregate, are caused by dental

treatment being applied for and rendered when the tissues are in an advanced stage of the disease. The proscrastinating patient appears for treatment with hard tissues highly decalcified and the soft tissues chronically inflammed, with advanced permanent regressive tissue changes. In a large percentage of cases, though the patient may think the cavity not advanced, the dental pulp is doomed, no matter how skillful the endeavor to save it. Pathological conditions of the teeth are progressively destructive.

There are some limited positive measures which, if applied early, are of tremendous importance in the maintenance of oral hygiene. The application of any agent that is bactericidal for the micro-organisms associated with dental caries, if it exerts no deleterious influence on the dental tissues, would be highly beneficial in warding off caries. Iodine and the aniline dyes give hope in this regard. They possess a penetrating power to enter gross and microscopic defects and thus fix in situ the destructive organisms; but their effect is transient, and the necessary frequency of their application decreases their value. It has been known for more than a generation that silver nitrate exerts a marked and positive inhibition against the carious infection of teeth. Its inhibitory action is more marked in dentin than enamel, but its use is of real practical and positive value, as in the treatment of caries in deciduous teeth, and in the very highly susceptible dentin at the cervix, and in cavity sterilization. Exposed dentinal tubuli with their contained protoplasm are easily infected, but a deposit of fine particles of metallic silver occludes the tubuli, and the application has an escharotic effect on the fibrils. Silver nitrate is decidedly bactericidal, and appears to exercise an influence in this regard in the hard dental tissues some time after its application. It is objected to by the profession and laity alike because of the black color of the precipitate. The color is hardly more baneful than that of amalgam or other fillings; and it is believed its more extended use would be beneficial.

For the early control of dental disease that has its genesis in structural defects, faults, constantly located in known positions, it has been suggested (4) that the areas be cut into, a preparation made, and filling inserted in accordance with the best technique of operative dentistry. Thus, before extended destruction of the hard tissue or

irritation to the pulp has taken place, or indeed the long train of sequelae of dental caries have occurred, a comparatively simple yet largely preventive dental operation is performed. Prophylactic odontotomy, as proposed, strictly implies cutting into structurally defective, though as yet non-carious, tissue, more specifically into developmental faults in the protective enamel. The proposition appears logical and conservative, yet its application is prevented by many grave dangers. In the whole domain of medical science operative procedures will probably continue to be therapeutic measures and not applied for purposes of prophylaxis, no matter how frequent the incidence of a pathological process in a particular tissue or location.

The advantages accruing from the treatment by filling of the pathological process in its incipience would be stupendous. The dental profession is well qualified to practice early therapeutic dentistry. Why is this class of dentistry not practiced more than it is? The bulk of dentistry today consists in extensive restorations of badly diseased teeth, questionable and difficult root-canal therapy, roentgenographic diagnosis, surgery for the removal of local focal infection, and prosthesis; not to mention the practice involving medicine as a whole in the attempted treatment of possible systemic metastatic infection secondary to dental infection.

X. SUMMARY

Dental caries is probably the most prevalent pathological condition consequent upon civilization. Tissue invaded by this morbid process is permanently destroyed. The greater part of the pathology of the dental and paradental tissues is directly or indirectly the result of caries. Mutilation of the arches as a sequela of caries is one of the most important predisposing causes of periodontoclasia. Many predisposing causes of caries are known, chief among which is the character of the diet. The exciting cause of caries is bacterial in nature and recent investigations indicate a specific bacterium or group of bacteria as etiologic agents. The occurrence of caries varies with the morphology of the teeth and age of the person. Developmental faults, proximal facets and exposed cervical dentin and cementum, are structural features which largely determine

localization of the carious lesion. The sequelae of dental caries are widely variant, and may be far reaching in the body economy.

Until more is known about the etiology of dental caries, preventive measures will probably remain relatively inefficient. The formation of dental tissues, as well as the health of the adult teeth, necessitates a diet possessing the original and intrinsic qualities of natural foods. Vigorous function as well as the maintenance of correct oral hygiene are essential. No method should be instituted which will destroy or in any way injure the normal covering of the teeth. Daily hygiene is far more efficacious than any form of periodic mechanical treatment. Until some more specific prophylaxis is discovered, the service of the skillful dentist, embracing chemotherapy and the filling of incipient carious cavities, should be earlier and more universally applied.

REFERENCES TO LITERATURE

(1) Black, G. V. 1916 Special Dental Pathology, Chicago.
(2) Delafield and Prudden. 1922 Textbook of Pathology, New York.
(3) Hopewell-Smith, A. 1919 Normal and Pathological Histology of the Mouth, Philadelphia.
(4) Hyatt, T. P. 1923 *Dental Cosmos*, p. 234.
(5) Leigh, R. W. 1923 *Military Dental Journal*, p. 183.
(6) Leigh, R. W. 1925 *American Journal of Physical Anthropology*, no. 2.
(7) McCollum, Grieves, *et al.* 1922 *Johns Hopkins Hospital Bulletin*, xxxiii.
(8) McIntosh, J., *et al.* 1924 *British Journal of Experimental Pathology*, p. 175.
(9) Malassez and Galippe 1910 Les débris épithéliaux paradentaires, Paris.
(10) Miller, W. D. 1890 Microörganisms of the Human Mouth, Philadelphia.
(11) Miller, W. D. 1905 *Dental Cosmos*, p. 913.
(12) Rodriguez, F. E. 1922 *Military Dental Journal*, p. 199.

A STUDY OF SKULLS IN THE AMERICAN MUSEUM OF NATURAL HISTORY IN RELATION TO PERIODONTAL DISEASE[1]

ISADOR HIRSCHFELD, D.D.S.

New York City

CONTENTS

I. Introduction 241
II. Non-infectious alveolar deficiency and root exposure 243
III. Alveolar plates 246
IV. Alveolar border 252
V. Everted alveolar border 255
VI. Interdental canals 259
VII. Summary 265

I. Introduction

The periodontist who aspires to further the science of periodontology has indeed a comparatively virgin field for his investigations. He may do pioneer work in his private practice, in hospitals, clinics, and other public institutions; he may avail himself of opportunities in the chemical, bacteriological, and histological laboratories; he may make a collection of study casts as an instructive source of periodontal education; and finally, he may do research work on skulls in museums, not only to check up observations made in private practice but also to corroborate or to correct statements made by investigators in the past.

The writer believes that a careful and intensive study of skulls has a definite place in the subject of periodontology. The invitation of your Programme Committee has spurred him on to do more concentrated work on skulls in the past few months and he humbly offers in this paper some of his findings. He hopes that his observations may prove helpful in the diagnosis, prognosis, and treatment of

[1] Read at a joint session of the American Academy of Periodontology and the Georgia State Dental Society, in Atlanta, Georgia, on October 8, 1924.

certain cases, and that they may aid the analytical periodontist to correlate, as nearly as possible, the anatomical variations as indicated by roentgenograms and otherwise, with the pathologic picture disclosed upon examination of both soft and hard parts. As a single paper cannot adequately cover the various lines of investigations, only a few topics will be discussed at this time, the others perhaps later.

In the study of skulls, everything may be blurred and uninteresting at first, and the specimens may only call out of a hazy memory the familiar landmarks reminiscent of the State Board Examination. As one's investigations become focussed on theories preconceived at the dental chair, this phase vanishes rapidly and the searching gathers ever increasing momentum, not only from the effort to prove or disprove these theories but also from new ideas inspired by the work on the dry specimens, which must in turn be checked up in office practice. A fascinating cycle is thus formed and a hobby may be unconsciously established. This has been the writer's experience and true to form, he enthuses about it possibly to a point of exaggeration. He would feel grateful to anyone in the audience who would point out and correct any such exaggeration.

When studying the dental apparatus in skulls one soon learns to avoid certain pitfalls. Most of the skulls in the museum have been exposed to the elements for a great many years and some perhaps for many centuries. It is easy to conceive how parts of the alveolar process might have been destroyed after death in such a manner as to give the appearance of the result of a suppurative periclasia, but the careful observer soon learns to differentiate conservatively. Then, too, there is the absence of the pericementum, the interarticular cartilage and the ligaments of the temporo-maxillary articulation, which often makes it difficult to establish the approximate relationship between the teeth and the alveoli, and between the mandible and maxilla. And sometimes, over zealous attendants, in an attempt to complete a set, unwittingly transplant teeth into different alveolar sockets of the same skull or into those of another skull.

A student of skulls will find the following topics, among others, especially interesting:

(1) The characteristic features of each race and geographic group.
(2) The morphology of the teeth; their characteristic types of occlusal wear, and the probable influences that produce them.
(3) Differences in the alveolar investment.
(4) Differences in form and depth of the glenoid fossae.
(5) The characteristic presence or absence of caries and alveoloclasia, and their probable relation to anatomy, diet, mode of living, environment, etc.
(6) The variations of the masticatory machine in the human skull, generally, in their probable relation to periodontal health and disease. (The periodontist will find this an especially absorbing topic for investigation.)

FIG. 1. Flathead Indian skull, showing extra heavy alveolar process. Note that the depth of the incisal fossa in the mandible deprives part of the middle third of the incisor roots of labial covering, despite the heavy alveolar border.

II. NON-INFECTIOUS ALVEOLAR DEFICIENCY AND ROOT EXPOSURE

In the course of work on dry specimens, the writer found the subject of non-infectious alveolar deficiency most fascinating, and he believes that a résumé of his observations from this angle should prove interesting. Very often the periodontist is confronted with cases presenting either individual teeth or groups of teeth on which the cervical part of the root is exposed, but without any clinical evidence or his-

tory of either local or systemic disease that might have been responsible for such a lack of periodontal investment. In many instances, very likely, he would consider this condition the result of a physiolo-

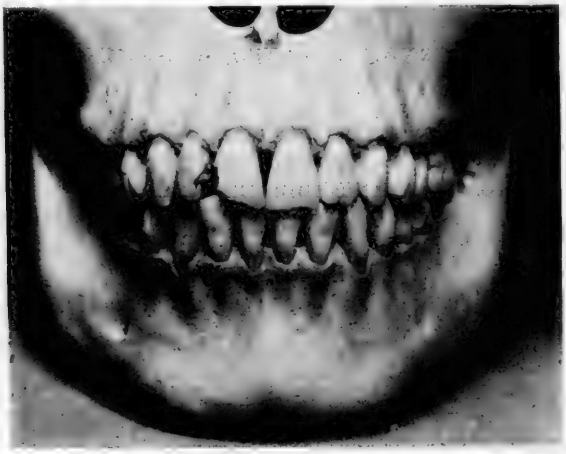

FIG. 2. Negro skull. Thin alveolar plate, showing contour of the roots. This evidently is not pathologic, and the exposure of the middle third of the lower left incisor root is probably due to post-mortem breakage.

FIG. 3. Hindu skull. Extremely thin alveolar covering. In this and in *fig. 2* the gingival form probably betrayed the contour of the roots.

FIG. 4. Hindu skull. The orientation of the lower left cuspid brought the labial side of its root within the incisal fossa, thus exposing the prominent contour. Note that the alveolar border on a level with that of the incisors is intact because of the lingual incline of the tooth, while the neck of the first bicuspid is exposed because this tooth stands somewhat labially to the arch.

FIG. 5. Hindu mandible. Coronal half of roots exposed labially on account of crowding of the anterior teeth beyond the arch of the labial plate. The clean condition of the root surfaces, in contrast with the betelnut stain of the crowns, indicates that although the alveolus may have been lacking, the gingiva covered those roots during life.

gic reaction, but, after eliminating such causes as the improper use of the tooth brush and toothpicks, he still finds himself at a loss in his search for the probable local etiologic factor. However, definite findings on skulls at the museum indicate that anatomical variations are responsible to no small extent for such root exposures.

III. ALVEOLAR PLATES

The alveolar plates tend to retain their respective buccal and lingual levels on a plane with the general scheme of the shape of the dental arch; i.e., when a tooth is tilted buccally, for instance, the buccal plate near the neck of the tooth will not be likely to follow it but rather will be either thinned down or entirely lacking, according to the extent and angle of the protrusion, while on the lingual plate opposite the same tooth the border may be proportionally thickened. Another instance is the case of a bicuspid in torsion, where the bucco-lingual diameter of the tooth is turned mesio-distally. Here, also, there is a tendency for the outer alveolar plates to keep their normal level in spite of the shortened bucco-lingual diameter of the socket; the result is a thicker alveolar process. Wherever the alveolar plate is very thin or entirely lacking over an individual tooth, very little pressure beyond the normal, such as strenuous tooth brushing, is required to cause a rapid recession of the gingiva. Where the alveolar plate is thickened in the wake of such a protrusion, the resulting right angle formed by the abnormally thick gingival crest with the crown of the tooth may invite either a mechanical trauma to the gingiva during mastication or an unsanitary condition. The alveolar border tends similarly to retain its original level during the physiological elongation of a tooth due to a missing opposing tooth. In this case the gingiva may or may not follow the tooth. The probable resulting exposure of the cervical part of the tooth is likely to produce, in a *dry* specimen, the optical illusion of an alveoloclasia, and *clinically*, the impression of a gingival recession rather than an elongation of the tooth.

When, in a mouth having a full complement of teeth, a particular group of teeth are used in excess of the others, either in the mastication of coarse foods or for vocational purposes, the roots of those teeth tend gradually to extrude from the alveoli in porportion to the

amount of occlusal wear of these teeth in excess of that of the other teeth. In appearance such a condition simulates an alveoloclasia because of the marked exposure of the roots, but is only an instance of

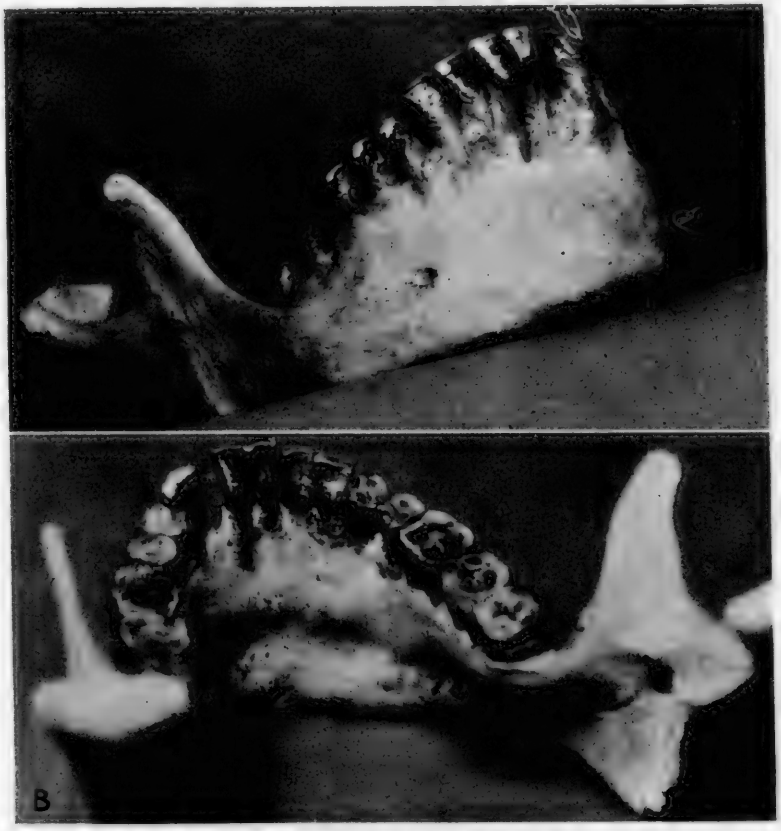

FIG. 6 (*A* and *B*). Unusual condition of central incisors, in which the crowns are almost in normal condition while the roots are extremely out of alignment—the right central, labially; the left, lingually. These teeth are thus entirely deprived of alveolar covering on their respective sides.

physiologic extrusion up to the opposing teeth. This is well illustrated in the skulls of Eskimos and of some Indians who use their anterior teeth excessively for purposes other than mastication. On

the other hand, where the teeth so used are the only ones present in the mouth, or where the entire denture is subjected to excessive occlusal wear, the roots tend to remain in the alveolar sockets and

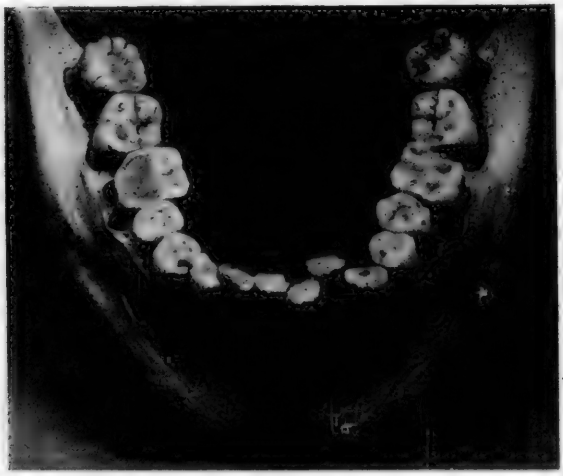

FIG. 7. Both lower second bicuspids slightly lingual to the arch. Note consequent thick buccal alveolar border.

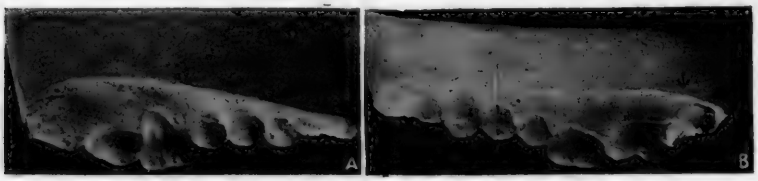

FIG. 8. *A*.—Elongation of upper right first molar into the space left by the extraction of the lower first molar. Note exposure of palatal root due to the continuation of mastication in this region. The palatal incline of the root plus the powerful pressure exerted here during mastication evidently produced a physiologic absorption of the periodontium. This case showed no clinical pathologic symptoms, but the eventual exposures of the root bifurcations certainly predispose them. *B*.—Buccal aspect of same cast showing the root not exposed and the gingiva following the tooth. This side is not influenced by the same pressure as the palatal nor do the buccal roots flare out as much bucally.

the occlusal surfaces may wear down to and even beyond the level of the gingivae. In such instances the mandible approaches the maxilla proportionately.

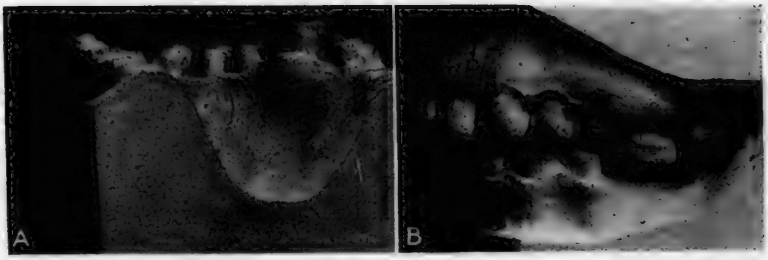

FIG. 9 (*A* and *B*). Case similar to that in *fig. 8*, except that two opposing teeth are missing here, and mastication was avoided on this side for many years. Therefore, there was no mechanical pressure to cause mechanical absorption of the palatal tissues. Note palatal gingiva following the root in its elongation.

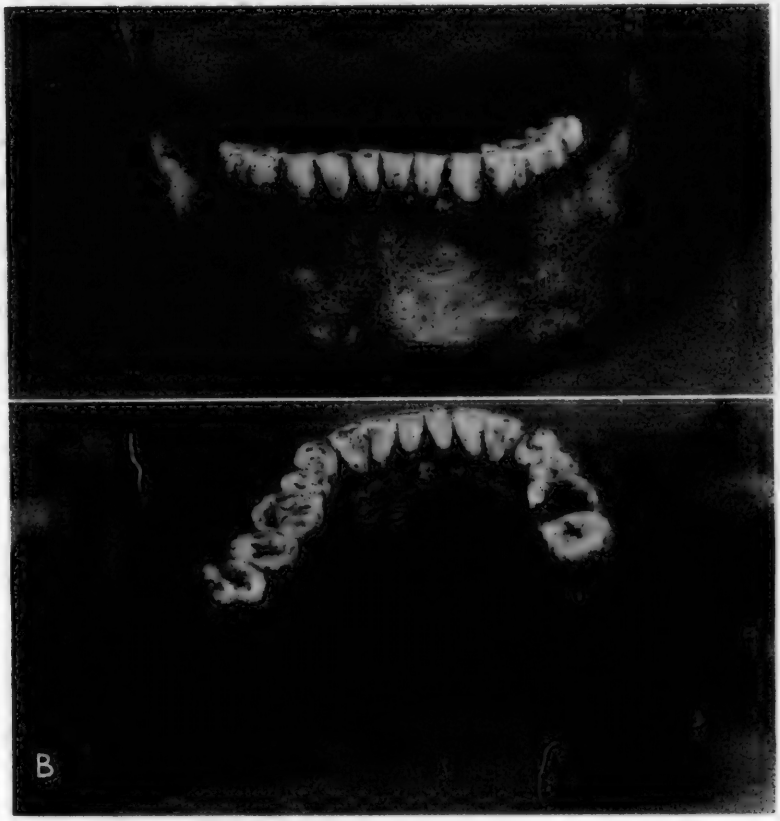

FIG. 10. Aztec mandible. *A*.—Healthy alveolar process; labial side. Note close approach of the alveolar border to the cemento-enamel junction. *B*.—Lingual side. Shows pressure absorption on lingual side, probably caused by salivary calculus.

When one of the buccal roots of an upper molar protrudes buccally beyond the other because of a slight torsion in position, the former will be likely to have less buccal plate, and consequently will be inclined to gingival recession (non-pathologic) at that point. Similar conditions occur both on the lingual and buccal side of lower molars in torsion.

An instance of physiologic root exposure, often diagnosed improperly as a socalled "dry pyorrhea," is that of the palatal root of the upper first molar. In the instance where its opposing lower molar has been missing many years, the resultant elongation partly accounts

FIG. 11. Hindu mandible, showing extensive salivary calculus formation, resulting in uniform absorption of entire lingual border of alveolus (non-pathologic). This and *fig. 10, B*, demonstrate that extensive salivary calculus formation in itself may not cause a suppurative alveoloclasia.

for the exposure. Where the opposing tooth is intact, and the palatal root of the upper molar is partly uncovered despite the apparent absence of pathologic indications, the explanation of these conditions, gathered from close observation of skulls, may be stated as follows: The first molar does more work and for at least five years longer than either of its neighbors; therefore, its occlusal surface is worn down in proportion. As the palatal cusp of the upper molar is really the working part of that tooth, it is the first to be worn down. This often results in a slight inclination of the tooth buccally and a consequent tipping of the palatal root lingually. This helps further to thin down the alveolar plate, which is usually very thin near the cervical

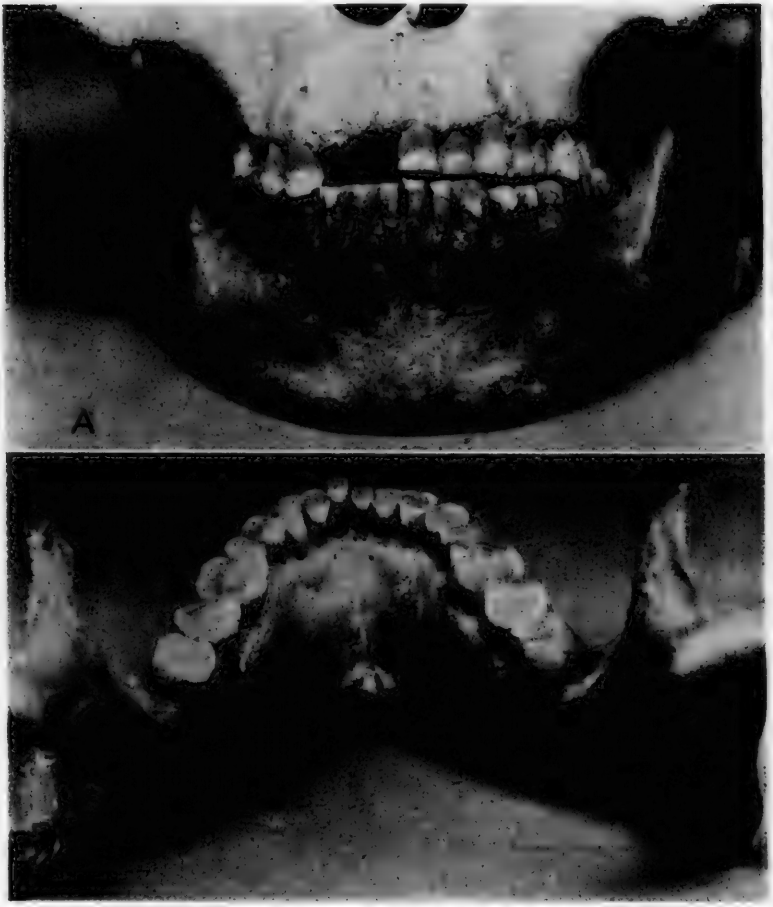

FIG. 12. *A*.—Eskimo skull, showing extrusion of anterior teeth due to extreme occlusal wear by uses other than mastication. *B*.—Lingual aspect of mandible. Note healthy condition of alveolar process. (The apparent elongation of the left central was caused by improper replacement by a museum attendant.)

region because of the extreme incline of this root. Added to this we have very powerful pressure exerted in that area by the tongue and mechanical trauma by the food during mastication. All these factors together seem to cause a physiological alveoloclasia and gingival recession at that point.

IV. ALVEOLAR BORDER

The alveolar border varies in form according to the character of the surface of the root with which it is in apposition. With comparatively few exceptions the same rule applies in the healthy mouth to the gingival margin, which to a certain extent, therefore, might be taken as a guide during the process of scaling under the marginal gingiva. Where the root surface is *flat* the alveolar border is straight; where it is

FIG. 13. Australian aboriginal skull, showing uniform extreme occlusal wear of the entire dentition. Note that the roots do not protrude from their alveolar sockets, in contrast to *fig. 12*. Note also the typical convex nature of the occlusal wear, which is the same in the mandible. This is one of the characteristics of the Australian collection at the museum.

convex, the alveolar border arches towards the apex; and where it is *concave*, the alveolar border arches towards the crown. Thus, for instance, around a normally shaped bicuspid when standing in torsion the labial and lingual alveolar borders may be either straight or arched occlusally. So also near the bifurcation of the roots of the lower molars on the lingual side, where there is a decided vertical groove; the alveolar border may actually taper occlusally.

FIG. 14 (*A*, *B* and *C*). Cast, showing extreme occlusal wear caused by tobacco chewing. The roots do not extrude from the alveolar process—a condition similar to that in *fig. 13*, except that the wear is concave. Note the approximation of mandible to maxilla.

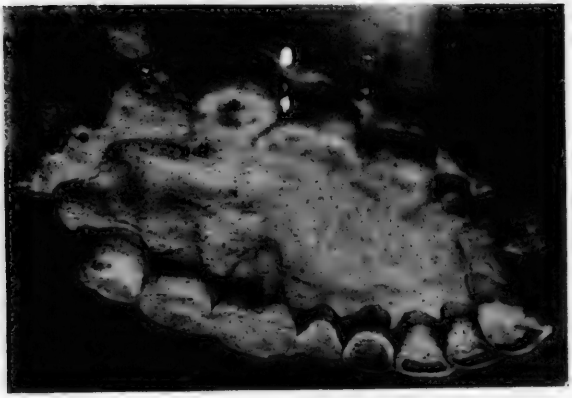

FIG. 15. Australian aboriginal maxilla. Exposure of the palatal root of the upper first molar; caused by extrusion of the tooth out of its alveolar socket, because of the extreme occlusal wear. The alveolar process in this skull is apparently in perfect condition.

FIG. 16. Drawings of everted border, illustrating quotations from a paper by Dr. Noyes.

V. EVERTED ALVEOLAR BORDER

Some of the findings of this study require correction of a statement made several years ago by an eminent member of our profession. On the mandible, beginning in the rhetro-molar triangle and running along or close to the margin of the buccal alveolar plate, is a raised line terminating usually opposite the first molar but often as far mesially as the first biscupid. This anatomical feature is present in the majority of mandibles to a greater or less degree of development, ranging from a mere raised line to an actual everted border of the alveolar plate not unlike the turning crest of a falling wave. In a very interesting paper, entitled "Changes in the Peridental Membrane,"[2] Dr. F. B. Noyes inferred that this everted border is the result of an inflammatory reaction. He wrote: "Fig. 1 is also a longitudinal section of the tooth and supporting tissues showing marked inflammatory reaction, but in this case the infection was apparently from within the gingival space. The bone forming the tip of the alveolar process is indicated at *B*, and it will be seen that there has been destruction of bone on the side of the peridental membrane and new formation of bone under the periosteum, causing the border of the alveolar process to become thickened and turned outward." The fact that he made special drawings to bear out his statement would indicate that he considers these findings important; but when he selects for his illustrations the everted border on the buccal plate opposite the mandibular molars, he evidently places the right thought in the wrong place. Observations on many skulls prove definitely that the accentuated alveolar border at this location is not the result of a pathologic process, but is a normal anatomical variation, which is developed, possibly, by the pull of the gingivae by fibres of the buccinator muscle. It also occurs, though rarely, on the buccal alveolar plate opposite the upper molars in the region where the other end of the buccinator muscle is attached. Of course in these locations the pericemental side of the alveolar plate may happen to be partly destroyed by inflammatory processes, thus producing a condition apparently coinciding with those illustrated in the drawings of Dr. Noyes.

[2] Noyes: *Journal of the National Dental Association*, 1920; February.

FIG. 17. Australian aboriginal jaws. Angular edge formed by the surfaces of the interdental alveolar crests and the buccal plate. Note the apparently perfect condition of the alveolar process.

FIG. 18. Australian aboriginal mandible. Same condition as in *fig. 17*, with the edge more prominent and rounded, especially in the molar region. Here, too, the alveolar process seems healthy.

The writer has often observed a very marked, uniformly thick condition of the cervical part of the alveolar plate, evidently as a necessary mechanical re-inforcement against leverage. He has also observed that in some skulls small growths of bone are deposited over

FIG. 19. Aztec skull. Unusual everted border in the region of the lower second and third molars, appearing like a thin turned down collar. The alveolar crest is in normal position.

FIG. 20. Hindu skull. The everted border here shown runs mesially past the second bicuspid. This anatomical condition is normal to very many skulls. Note the very heavy everted alveolar border on the maxilla (which occurs infrequently); also limited to the bicuspid and molar region. Generally speaking this skull does not show evidence of alveoloclasia of the buccal plates.

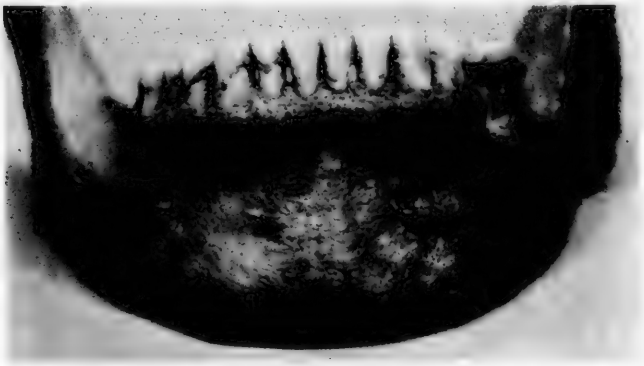

FIG. 21. Unusual thickness of alveolar plate over cervical half of root. The pericemental side of the plate is evidently intact.

FIG. 22. Nodular deposits of bony tissue over individual teeth. Although the pericemental side of the alveolar plate seems quite intact in the maxilla, there is very marked destruction in the mandible. Between the left lateral and cuspid, the septum is entirely destroyed, while the buccal plate in this location shows marked exostosis. In the bifurcation of the lower first molar, the destruction is extreme.

individual teeth. In both instances there may be no macroscopic evidence of destruction of the pericemental side of the alveolar plate.

On the other hand, such abnormal osteogenetic formations may be accompanied by destruction of the crest only, or may involve the pericemental side of the plate. This latter condition is likely to be the macroscopic setting in which Dr. Noyes's microscopic picture might exist.

VI. INTERDENTAL CANALS

In roentgenograms of the anterior region of the mandible, the careful observer may occasionally find what appear to be linear rarefactions running vertically in the alveolar septa, particularly between

FIG. 23. Marked exostosis of buccal and palatal alveolar plates near the upper second and third molars on both sides. The destruction of the peridental side of the process permits extreme mobility of the teeth.

the central and lateral incisors. Starting at various points opposite the middle third of the root they run down into the body of the mandible below the level of the root apices. Here they usually fade out quite abruptly. Towards the crest of the septum they appear to terminate in either a tapering or a rounded end, or appear to be continuous towards the crest with a series of emphasized trabeculae, or again with a pathologic rarefaction, probably the result of a suppurative perclasia which is progressing apically. When the writer first observed these linear radiolucencies several years ago, he suspected that they were osteorarefactions caused probably either by a reaction

to incipient pyorrheal infections, or by some form of mechanical trauma, or that they were actual pyorrheal crypts. Many repetitions afterwards, easily disclosed their normal anatomical nature. How-

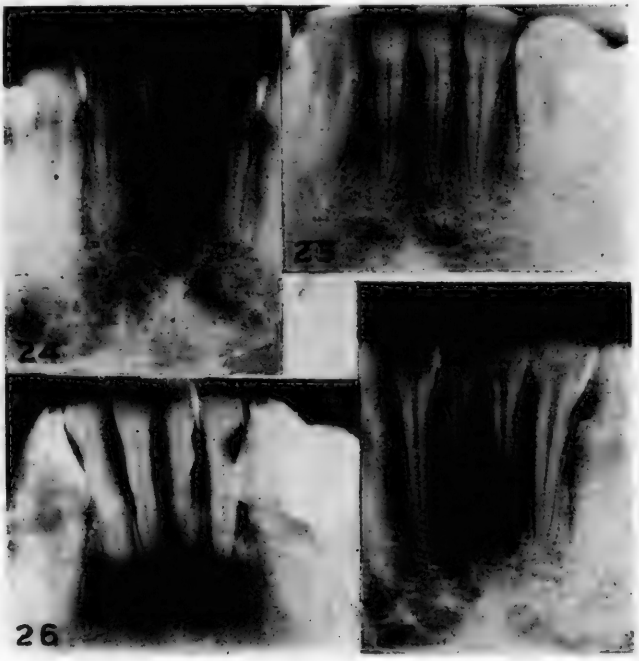

FIG. 24. Dry specimen. Average normal alveolar structure, with no special translucent features.

FIG. 25. Marked septal radiolucencies. Clinically, no pathologic symptoms were present.

FIG. 26. Interdental canals running up from the body of the mandible into the interdental processes between the centrals and laterals on each side. Note that the rarefaction at the apex of the right lateral evidently has no connection with the interdental canal on that side.

FIG. 27. Dry specimen. Roentgenographic fusion of interdental canals with chain of emphasized trabeculae. Anatomically these are not fused, the upper end of the interdental canals passing lingually to the trabeculae, and ending in a foramen on the lingual plate.

ever, it was by the use of the skulls that the writer was able to obtain more definite information. Anatomically, each of these shadows represents a canal and, because of its interdental location in the roent-

genogram, the writer calls it an interdental canal. Each interdental canal terminates in a foramen usually on a lingual plate of the alveolar process at some point between the teeth at a level generally opposite the middle third of the roots. This foramen like the canal itself varies in diameter from over a millimeter to microscopic size.

Although only two interdental canals appear on the roentgenogram in the majority of cases, frequently one finds four canals. In such cases, the two additional ones are found on each side between the laterals and cuspids. In comparatively rare instances, a fifth canal

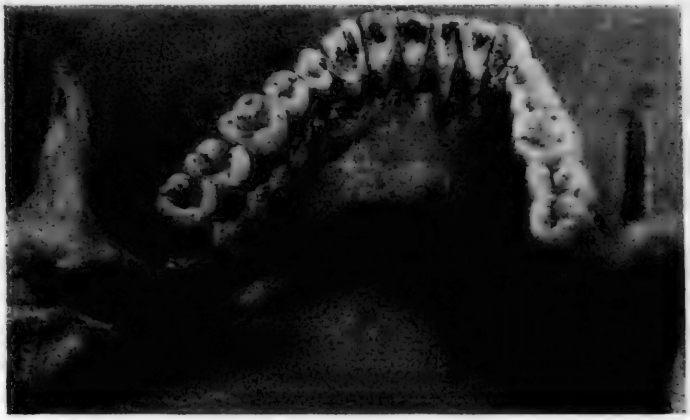

FIG. 28. Syrian mandible. Lingual aspect of mandible from which roentgenogram in *fig. 27* was made. This illustrates foramina at termination of the interdental canals. Note that the multiple foramina on the left side form a deltoid exit for the same canal. Also note the lack of alveolar covering on the right central incisor because of its position, lingual to the arch.

is found between the centrals. Therefore, roentgenographically these canals are landmarks which help to identify broken down roots of the various incisors and also worn down cuspids which, in roentgenograms, often simulate incisors in outline. So, for the purpose of anatomical identification, the following formula might be employed: When only two interdental canals appear, there is one on each side between the central and lateral incisors; when there are four canals, the outer ones are between the laterals and incisors; when there are five, the middle one is between the centrals. The uniformity of this

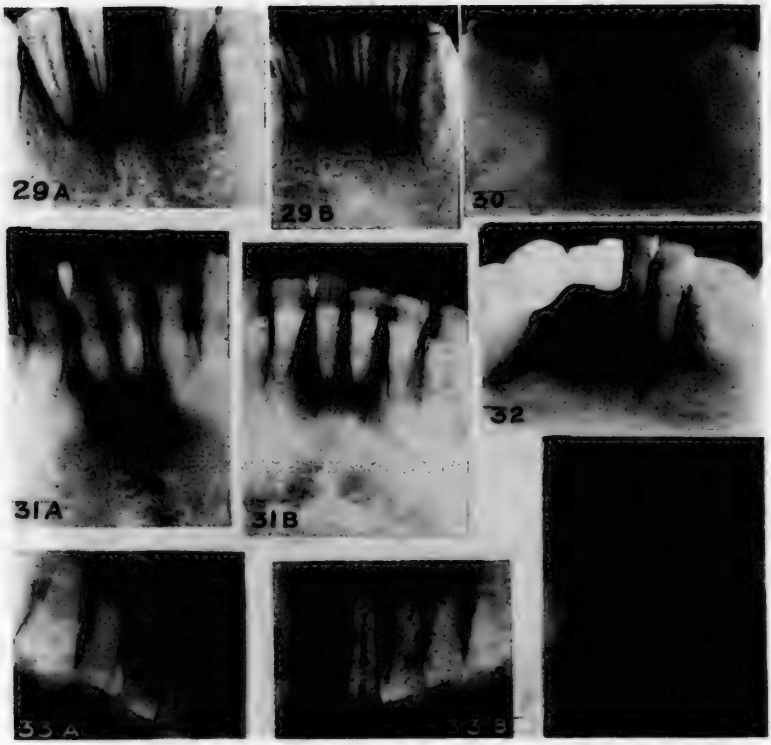

FIG. 29 (*A* and *B*). The interdental canals here may appear to be continuous with, and the result of, the pathologic destruction, but in reality they are a normal anatomical feature. The disease may extend down as far as or into the canals, but it does not produce them. As these canals may be in actual communication with the infected areas, the extreme importance of establishing a local and systemic immunity in the treatment of a suppurative periclasia becomes evident.

FIG. 30. Clear roentgenographic picture of the foramen of the interdental canal between the right central and lateral. The clearness of its circular outline is probably made possible by the destruction of the labial plate, caused by the abscess about the apices of the centrals.

FIG. 31 (*A* and *B*). Dry specimen. *A*.—Normal angle, showing apparent fusion of interdental canals with septal trabeculae. *B*.—Foreshortening of the same specimen demonstrates that, anatomically, the canals are not continuous with each other.

FIG. 32. Clear roentgenogram, showing the interdental canals terminating in circular foramina in the lingual alveolar plate.

FIG. 33 (*A* and *B*). Interdental canals on each side of both upper laterals. Maxillary interdental canals very seldom appear in roentgenograms.

FIG. 34. Linear radiolucency situated midway between the upper centrals and separated from them by healthy alveolar structure. It usually tapers apically, and its broadest part is at the alveolar crest. In this location it indicates the existence of a partial cleft in the median suture of the premaxillary bone, but is not a pathologic condition.

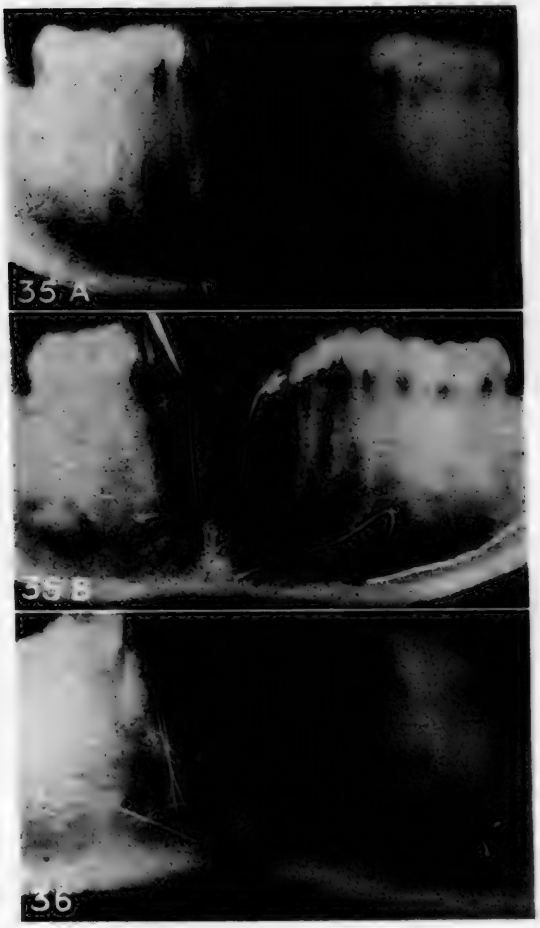

FIG. 35 (*A* and *B*). Dry specimen. *A*.—Shows the interdental canals apparently merging with the septal trabeculae, but not appearing to reach down far beyond the apical level. *B*.—Same mandible with wires entering at the foramina of the interdental canals, the mental foramen, and the inferior dental canal. This easily shows the course of an interdental canal which is usually not discernible in a roentgenogram of a living person.

FIG. 36. Endetulous anterior alveolar process, with two sets of wires running through the mandible: one through the dental branches of the inferior dental canal, and the other through the interdental canals, showing the general direction of both in relation to the inferior dental canal.

arrangement makes each of these canals a landmark, which may guide the dentist with almost the same certainty as the North star guides the mariner.

As described previously, these interdental canals may appear to be continuous with other interdental translucencies. Therefore, it is very easy to understand how the destruction of the alveolar process in the case of a mesio-labial suppurating pocket running along a lower lateral incisor, for instance, may appear roentgenographically to be a continuation of the interdental canal running lingually to it though it does not actually approach it. In his diagnosis of the interdental area, the operator should take this fact into consideration, just as he would in the case of the mental foramen in relation to the apical region of the lower bicuspids, and the incisive foramen in the apical region of the upper centrals.

As stated earlier in this paper, the foramina at the ends of the interdental canals vary greatly in diameter, thus transmitting naturally either larger or smaller blood vessels, lymphatics, etc. The interdental canals evidently play an important rôle in supplying the gingival tissues. Therefore, it would be interesting to know the influence of the variations in size upon resistance to infection, their influence on prognosis, and how they function in an atrophy or hypertrophy of the gingiva. In the case of the patient who had the largest interdental canals I have ever seen, a fairly advanced suppurative periclasia, treated by a student in the clinic, cleared up in record time.

Other interesting thoughts occur to me relative to these interdental canals. For instance, in the case of a slowly advancing suppurative periclasia, do these minute channels tend to remain open; or do they recede, followed by calcification of the canals, as in the case of the pulp and pulp chamber in the path of irritation? In either case, does the periodontium after treatment at that point atrophy, or is it subject to a greater tendency to reinfection because of a probable lessened circulation? On the other hand, what is the relation of these canals to that type of gingivitis and periclasia which is strictly interproximal in character. May not the visibility of the interdental canal in some instances be utilized as a diagnostic aid in confirming a calcium deficiency such as ricketts, tuberculosis, etc., just as roentgenograms of the tibia help to confirm them?

VII. SUMMARY

1. In the diagnosis and treatment of periodontoclasia, it is naturally imperative that the operator should be familiar with all the variations of the normal, abnormal, and pathologic anatomy of the periodontium.

2. One may familiarize himself with these variations in the hard parts of the masticatory apparatus only through a close study of large numbers of skulls. Observations based upon the examination of a small number of skulls are apt to lead to incorrect conclusions. Therefore, the museum is probably the best available place for such study.

3. In the study of dry specimens it is essential to guard against confusion of post-mortem damage with destruction resulting from disease during life.

4. Several clinical pictures that were difficult to explain by an examination of the mouth alone were easily diagnosed after observations of the repeated occurrence of certain anatomical variations in corresponding conditions in the skulls.

5. Although faulty metabolism and malnutrition, local or systemic, may be responsible for many instances of periodontoclasia, infectious and otherwise, a large number of cases of alveolar deficiency and root exposure are strictly nonpathologic in origin and mainly an expression of mechanical wear and anatomical variation.

6. The study of dry specimens greatly helped the writer to change speculations into certainties concerning the normal character of the interdental canals and their differentiation from other linear radiolucencies in the interdental alveolar process.

The writer takes this opportunity to express his appreciation of the privileges extended to him by the officers of the American Museum of Natural History and to thank them for their kind cooperation. He also acknowledges the able assistance of Dr. S. M. Getzoff, of New York, in making the roentgenograms of the dry specimens.

730 Fifth Avenue

EXTENSION COURSES IN DENTISTRY

A Contribution to Research in Dental Education[1]

RICHARD R. PRICE, Ed. D.

Director of University Extension, University of Minnesota

The short course as an educational device has arrived. Its merit is extreme flexibility in method, scope, and duration, and concentration upon limited objectives or specific fields of endeavor. The short course may demand the full time of the student for a period varying from three days to three months; or it may take only his evening hours two or three times a week for six, eight, ten, or twelve weeks.

The subjects of study vary rather widely. There are offered in the universities and colleges of the United States, short courses in agriculture, home-making, newspaper work, bee-keeping, retail merchandising, salesmanship, citizenship, dentistry, medicine, surgery, physiotherapy, embalming, and a number of other subjects. There is one clear line of demarcation that separates these short courses into two major groups. One group is composed of short courses that tend to give the student in brief compass a sweeping survey of the superficial aspects of a fairly wide field of study. These are essentially undergraduate courses. The other group of courses deals with students who are already equipped with the fundamental knowledge required in the field of study, but who lack first-hand acquaintance with recent advancement, improved methods, new discoveries, or developed technique. Such courses are designed primarily for graduates or practitioners of a profession; and the time is usually spent intensively upon a narrowly-circumscribed or highly specialized portion of the general subject. It is to the consideration of some short courses of the second sort that this article is devoted.

It is believed that there may be some interest in the experiences of

[1] Submitted for the Faculty of the College of Dentistry of the University of Minnesota.

the University of Minnesota in conducting short courses of various kinds, but especially in the field of dentistry. There is reason to believe that the short course as a teaching method and as a means of post-graduate professional instruction has made a distinct advance in this institution. It is quite probable that the work of this kind done in dentistry is unique. In the University of Minnesota, while the teaching of short courses is done by regular members of the faculty of the school or college concerned, the management, administration, and finances are handled by the General Extension Division, with the exception of the work in agriculture and home economics. As an example of an annual program of short courses, the following list is given of such courses conducted under the auspices of the General Extension Division during the year 1924–1925.

Medicine	2 weeks
Surgery	2 weeks
Pathology	1 week
Obstetrics	2 weeks
Pediatrics	2 weeks
Physiotherapy	1 week
Preventive Medicine	1 week
Anesthesia and extraction	10 days
Monson Principles	10 days
Prosthetics	10 days
Embalming	12 weeks
Color and design	10 days (two courses)
Textiles	10 days (two courses)

In other years short courses have also been conducted in retail merchandising, citizenship for women voters, and scoutcraft. The demand for these courses, and the variety of subjects pressing for treatment, tend to expand each year. The courses have been made almost entirely self-supporting.

The development in the field of dentistry has been particularly interesting, and in some respects unique. Moreover, the outlook for the future in this line of activity is exceedingly promising. One reason for this is that during the past ten or fifteen years there have been great changes in the theory and technique of dentistry: new ideas of dietetics as related to teeth have been promulgated, the subject of focal infection and its results has been thoroughly explored, the X-ray has made its contribution to diagnosis, and the technique of ortho-

dontia and of prosthesis has been greatly improved. As a result, graduates of ten or more years have much to learn, and the short course at the College of Dentistry is the most approved means of bringing oneself and one's technique up to the minute. In order to compete with the up-to-date methods and procedures and technique of the newer graduates, the older dentists in the practice have felt the necessity of resorting at intervals to the colleges of dentistry where the latest results of experimentation and research are available, there to obtain and carry back for the benefit of their own patients the best that the most advanced exponents of modern dental science have to offer. These results are obtained with a relatively small expenditure of time and effort because the students are already trained, skillful, and experienced practitioners, with a background which enables them easily to grasp and apply what is explained in lectures and demonstrated in clinics.

The development and evolution of the short courses in dentistry at the University of Minnesota was made possible and effective through close and cordial coöperation between the faculty of the College of Dentistry and the General Extension Division. The beginning was made in July, 1917, when a general short course for dentists was conducted for one week at the College of Dentistry. The course included intensive lectures and clinic work lasting throughout the day, and the instruction was given entirely by regular members of the College and of the University Department of Anatomy. There were fifty registrants, which was the maximum number that could be accommodated.

In May and June of the following year, 1918, three more highly specialized courses were conducted: one in crown-and-bridge work, lasting two weeks and attended by nine registrants; one in porcelain jacket crowns lasting one week, with ten registrations; and a one-week course in oral surgery attended by fifty-seven registrants. On this occasion, also, the instruction was given by regular members of the College of Dentistry and of the Department of Anatomy. It should be noted, also, that again the intensive lectures and clinic work lasted throughout the day.

The year 1919–1920 saw a great development in the short-course offerings. During the summer of 1919 a six-weeks course in hospital

dentistry was conducted through the coöperation of the College of Dentistry and the Medical School, with the administrative agency of the General Extension Division. *No fees were charged.* The course was divided into three sections, as follows:

Section I.—Series of lectures only; 26 registrations.

Section II.—Lectures, ward, and library work, occupying six half days a week; 3 registrations.

Section III.—Lectures, ward, and library work, and actual dental work on hospital patients, requiring full time; 6 registrations.

Following this course, in October, 1919, four men enrolled in a twelve-months extension course in hospital dentistry. These students were assigned to the University Hospital for dental work under supervision. *No fee was charged for the course.*

It was in September, 1919, that the most ambitious forward step was taken, when a short course in prosthetic dentistry was conducted for four weeks. One of the best known experts in this branch of dentistry in the country was brought to Minnesota for the occasion and he was assisted by the chairman of the division of prosthetics in the College of Dentistry. The month was devoted to a complete and comprehensive course of lectures, and laboratory and clinical work on scientific technique in the construction of artficial dentures. Patients were brought in by dentists registered for the course or were supplied by the College on request. A very gratifying interest was shown in this novel course, as indicated by the registration of forty-eight men, who came from states scattered across the country from New York to California. This registration is significant in face of the fact that because of the heavy expense involved it was necessary to charge a fee of $100 for the course. After the first year the fee was $250. So great an interest was shown in this work all over the country that it was decided to repeat the course in the summer of 1920, and then to follow it up with an advanced course lasting two weeks.

Without going any further into details, it may be stated that the course in prosthetics under the same expert instructor was held for four weeks in the summer of 1920, with nineteen registrants; and was followed by a two-weeks advanced course with thirty-two registrants. The following summer three such courses were held, one of four weeks

and two advanced courses of two weeks each. The registrations were fifteen, nine, and eighteen, respectively. The four-weeks course only was conducted in the summer of 1922, with nine persons enrolled. In 1923 the four-weeks course was conducted for eight persons and the two-weeks advanced course for five persons. Thereafter, this particular form of short course with an instructor brought in from outside was discontinued.

In the meantime, in the spring of 1920, the short course in crown-and-bridge work was resumed. This was a two-weeks course, consisting of the study, diagnosis, and application of principles involved in the use of vital teeth for crown-and-bridge work. The dentists were required to go through the technical procedures in the preparation of teeth for full crowns and partial-crown abutments. This technical work was supplemented by illustrated lectures. There were twenty registrations. This course was supplemented the following week by a six-days course in minor oral surgery conducted by members of the staff of the College of Dentistry. There were lectures, clinics, and daily demonstrations in extraction and other minor forms of oral surgery. This course drew twenty-two registrants.

It is evident that the one-week and two-weeks short courses just described were peculiarly available to the practising dentists of Minneapolis, St. Paul, and the small towns immediately adjacent to the Twin Cities or within easy automobile-driving distance. These men could easily arrange to keep appointments with their patients and yet attend these courses. As a matter of fact the registration at these courses was largely made up of the ambitious and progressive elements among the dentists practising within easy reach of the University of Minnesota. Such was not true, however, of the registration in the summer short courses in prosthetics. The membership of these classes was drawn from all over this country and from Canada.

Soon after the close of the War there began to be felt a demand for training in dental mechanics for young men and women who were not qualified by previous education to enter the College of Dentistry. Most of the applicants were Veterans Bureau trainees. A one-year course for such persons was accordingly prepared and for administrative purposes was turned over to the Extension Division. The teaching and training was done in the College of Dentistry. The work was

begun in the year 1920–1921 and continued for three years. The demand having then virtually ceased, the work was discontinued. It is mentioned here only because it was a non-professional course and was administered by the Extension Division.

During the academic year 1923–1924, a further advance was made. The district dental societies of Minneapolis and St. Paul made arrangements for a series of short courses to be conducted for their members in the evenings at the College of Dentistry. The full laboratory, clinic, and equipment facilities of the institution were made available and the instruction was given by members of the staff. Each class met once or twice a week and spent a full evening of three hours. The point should be emphasized that these were evening classes and were available, therefore, only to dentists in the Twin Cities and the suburban towns. These men were able to save their full office hours and yet obtain the desired instruction. The specialized courses given, in this case, were as follows:

Course I.—Prosthetics; ten sessions, twenty-two registrations.
Course II.—Porcelain veneer crown; eight sessions, sixteen registrations.
Course III.—Gold foil; eight sessions, nine registrations.
Course IV.—Crown-and-bridge; ten sessions, twenty-one registrations.

The fee charged for each of these courses except the second was $15.00; for the second it was $12.50. During the year 1924–1925, the course in prosthetics was repeated in ten evening sessions with a fee of $16, and a registration of twenty-four. A course in anesthesia and extraction in ten evening sessions drew an enrollment of twenty-three. This course had to be repeated for twenty-nine nurses and dentists' assistants. A third course, given in ten evening sessions, was in Monson principles applied to full and partial denture work, crown-and-bridge work, and orthodontia. Twenty-eight dentists enrolled in this course. The fee for each of these courses was $16. All of them consisted of lectures, demonstrations, and laboratory work by members of the class in the construction of practical cases.

One further step in the evolution of the short course in dentistry at the University of Minnesota should be recorded. It has apparently become the approved custom in the profession of dentistry for cer-

tain practitioners who have become uncommonly proficient or expert in certain lines, or who have developed a new and efficient technique or a new process of treatment, or who have invented a new instrument or a new piece of apparatus, to travel about the country holding demonstrations and clinics at which they divulge these secrets to their fellow practitioners and give them training in the practical applications. Sometimes these demonstrations and clinics are held before dental societies or conventions; at other times groups of dentists club together and thus subscribe for a course. The most notable feature of this system is that the man conducting the clinic or demonstration almost invariably charges a very high fee—high even from a professional standard—and this in spite of the fact that those who pay are fellow members of the same profession, presumably actuated by the desire to improve their skill, knowledge, and proficiency in the interest of suffering humanity. It is not the writer's purpose to comment adversely on this practice, but merely to set forth the facts. However, it is not without interest to observe that in the medical profession, which is very closely related to dentistry, a practice such as that described above would be deemed wholly unethical and would not be countenanced.

When the short courses in dentistry at the University of Minnesota were first developed, the current practice in the profession was adopted of paying high professional fees to the instructors, whether these were drawn from the staff of the College of Dentistry or from the ranks of the specialists and experts among the practitioners. This practice involved, of course, the collection of correspondingly high tuition fees from the students. During the year 1923–1924, those who were vested with the administration of these courses became convinced that the financial methods outlined above were indefensible from the standpoint of a teaching institution supported by public taxation. It was determined, therefore, that instructors thereafter, from whatsoever source secured, should be paid at the unit rate established in the College of Dentistry for similar services, and no more; only such courses would thereafter be offered as could be conducted on this basis; and tuition fees would be placed on a minimum basis—*only enough being charged to cover expenses incurred, with a small allowance*

for overhead. This system has worked satisfactorily, and is approved both by the College authorities and by those who enroll for the courses.

A further advance is now under contemplation. It has been found that many of these courses can be given away from the institution. It is now proposed to conduct peripatetic clinics and demonstrations in several Minnesota towns. These short courses would be conducted in concentrated or intensive form at week ends—say, Friday evening and all day Saturday—under the auspices of local dental societies. Some convenient center will be selected and the dentists will be invited in from the neighboring towns. All arrangements for registering students, financing the course, and securing a suitable meeting place will be in the hands of the local committee. Instructors will be sent from the University and *will be paid only at the rate of their regular unit salaries, plus the necessary traveling expenses. Tuition fees will thus be reduced to the minimum.*

It is obviously too soon to predict the success of this new enterprise; but it is not beyond the bounds of possibility that within the next five years the whole state of Minnesota will be dotted over with these short courses, held in towns where there are good hospitals and adequate dental facilities. In this, as in other ways, does the University of Minnesota attempt to vindicate its claim that the whole state is its campus.

THE ORIGIN AND EVOLUTION OF THE HUMAN DENTITION

Reviews of Gregory's Book

CONTENTS

I. Translation of a review by P. Teilhard (France) 275
II. From a translation of a review by V. Giuffrida-Ruggeri (Italy) 279

I[1]

Prof. Gregory, well known to zoölogists through his work on the "Orders of Mammals," has devoted himself for several years past to the zoölogical and palæontological study of the primates. In 1916 he gave, in the Bulletin of the American Museum of Natural History (vol. XXXV, art. XIX, pp. 239–355), his first work "On the Evolution of the Primates." In 1920 he published in the series of memoirs of the Museum at New York (New Ser., vol. III, part II) a magnificent monograph "On the Structure and Relations of *Notharctus*, an American Eocene Primate." In the work that we are now reviewing he gives a general exposition of the results to which he has been led through his prolonged researches upon an exceptionally large number of recent and fossil "documents." The study relates directly to the evolution of the teeth, but it contains much more than a narrow description of the dental tubercles. As the author excellently says, "a theory of the evolution of the teeth, to be well-founded, must rest upon a broad palæontological and morphological base, and the study of taxonomy, or classification of animals according to their phyletic relationships, is the very corner-stone of such a base."

In connection with the teeth, Gregory gives us a veritable review of the vertebrates. From the Silurian to the Quaternary the author distinguishes and describes successively twenty-six stages in dental

[1] A translation of a review of Dr. Gregory's work by P. Teilhard in *L. Anthropologie*, xxxii, 1922 (September). Teilhard, one of the leading palæontologists of France, is the author of important memoirs on the Eocene mammals of France, and exceptionally well qualified to review critically Dr. Gregory's book.—*Ed.*

evolution, culminating in the human type. The principal stages are as follows: Primitive fishes; primitive and progressive crossopterygians; primitive amphibians; primitive and progressive cotylosaurs; primitive pelycosaurs; theromorphs (early, intermediate, and advanced mammal-like reptiles); protodont and pre-trituberculate mammals (Triassic and Jurassic); pre-placental insectivores (Cretaceous) and pre-primates (Paleocene); primitive lemuroids (*Pelycodus*, Lower Eocene); primitive pro-tarsioids (*Omomys*, Middle Eocene) and progressive tarsioids (*Necrolemur*, Upper Eocene); pre-catarrhines or "supertarsioids" (*Parapithecus*, Oligocene); primitive anthropoids (*Pliopithecus*); pre-human anthropoids (*Dryopithecus*, Miocene); human precursors (*Pithecanthropus*); Heidelberg race; inferior human type (Neanderthal race); and superior human type (*H. sapiens*, microdont). Naturally the later of these numerous stages, those beginning with the Paleocene, are studied more at length than the others. However, concerning the theromorph reptiles and the Mesozoic mammals one will find original views and details that are not well known.

To illustrate his demonstrations, Gregory has grouped an enormous number of figures, many of them from his earlier works in the publications of the Museum at New York, and from many other memoirs. Of the 244 photographs in the work we count 24 photographs of dentitions of marsupials, and 140 photographs of skulls of primates (reproduced in part from Elliot's work). The remainder of the illustrations is composed of line drawings admirably arranged for the comparison of the forms considered. It is the first merit of Gregory's book that it constitutes a repertoire, unique of its kind, of all that is certainly known of the osteological material for the history of the primates. But it is better than a simple accumulation of documents; it contains a solidly organized scientific doctrine. At the end of his vast investigation the author is in effect led to present, first, an original standpoint with regard to the theory of trituberculy; secondly, a very arresting conception of the manner in which the evolution of animal forms must have taken place; finally conclusions, equally very firm, upon the relatively recent formation of mankind.

With regard to the general evolution of the teeth of mammals,

Gregory completes the Cope-Osborn theory by very ingeniously annexing to it the views of Wortman. In the upper molars, he says, we must distinguish two triangles of cusps; first, a primitive triangle, recognizable in the Mesozoic mammals and (by retrogression?) in the centetid insectivores, was formed from a central protocone homologous (as Wortman will have it) with the principal cusp of the premolars, and of two external cusps (parastyle and metastyle). Secondarily, this primitive protocone is divided into paracone and metacone, and a new and more internal single cusp, the protocone of Osborn, homologous with the deuterocones of the premolars, is formed in response to the heel of the lower molars. Thus a secondary triangle has appeared internal to the primary one. It is from the secondary triangle alone that all of the final modifications of the molars among placentals have issued. These novel views of Gregory's appear to represent a real progress in the tritubercular theory of the teeth. They are supported by numerous examples, and also by a particular theory of the occlusion of the teeth, which is constantly utilized in the course of the book to interpret the relations between the cusps in the upper and lower jaws.

After having cleared up the confusion of the fundamental homology of the cusps of the teeth, Gregory seeks to follow their variations throughout the primate series. This study has led him to make categorical and repeated declarations concerning the fashion in which it seems to him we ought to understand the rhythm and the curve of animal evolution. It appears to him that two conceptions especially should be rejected; that of the uniform velocity of zoölogical transformations and that of their irreversibility, wrongly understood. Besides the regular evolution of animal forms, the development of which has been dominated without interruption by the same physiological functions (e.g., the Equidæ), it is necessary to make a place for rapid transformations by "revolution," which must have occurred among animal series whenever profound modifications were induced in the mode of life, as in the passage from aquatic or arboreal to terrestrial life, the adoption of the bipedal posture, etc. An important change in function must necessarily have led to a reconstruction and a readjustment of organs, that is to say, to re-diminutions,

re-augmentations, and to pronounced divergencies. Because they have not taken account of these oscillations and reactions, palæontologists have thought themselves obliged to dissociate zoölogical groups into a multitude of parallel lines.

Applying these considerations to the human species, Gregory takes a strong stand against those naturalists who wish to remove the origin of man to an impenetrable past. Conformably with the traditional views of Darwin, Lartet, Gaudry, Dubois, Schlosser, he thinks that the human stock branched off from the other anthropoids in the Miocene and that they were derived from the *Dryopithecus* group. These have the large canines and the lower molars of apes, but this reason is not sufficient to remove them from our line of ascent. The conditions in which the points of all the lower teeth have been reduced to the same plane and the diastemata have been closed in the human lower jaw, are just as secondary in us as in *Homalodotherium*. They have taken place in connection with either the reduction of the face or with changes of habits of feeding and defense. Through *Dryopithecus* the human line joined the series *Propliopithecus*, *Parapithecus*; and from there it would be lost in the group of tarsioid forms in the Eocene.

Palæontologists will certainly dispute these daringly conservative views, as the author expects. But they will be forced thereby to reflect seriously. They will agree with Gregory in having vigorously defended the right of their science to pronounce the final word upon questions of phylogenesis. To those anatomists who wish to practise comparative zoölogy without knowing the past of life, as well as to those who hesitate and always demand more proofs because they do not know how to read those that are before their eyes, Gregory opposes his expert testimony with an authority and a conviction which reaches the tone of true eloquence. One recognizes in him the master who has attained a well-based personal intuitive knowledge of nature.

It is unfortunate that the difficulties encountered by many readers in procuring this book will be an obstacle to the distribution of a work which is one of the most important contributions that have been devoted to the palæontological study of man for a long time.

II[2]

The work is divided into five parts. In the first part the author is concerned with the course of evolution from the fishes of the Silurian to the mammals of the Upper Cretaceous. The second part treats of the evolution extending from the placentals of the Paleocene to the lower primates. Here the author shows the complete inanity of the pretension of Wood Jones, according to which the lemurs would have no part in the source of the primates. The third part is concerned with the primates with large eyes and short jaws. In discussing in great detail the platyrrhine monkeys, the author shows how erroneous is the opinion of Ameghino and of Sera, according to which man and the primates of the Old World would have come from the platyrrhines of the New World. This judgment is definitive, because it is formulated by an author whose competence is incontestable. The fourth part is composed of two chapters. In the first the author treats the family of the Cercopithecidæ in which he includes *Oreopithecus*, and he arrives at the conclusion that the monkeys are outside of the line of evolution leading to the anthropoids and to man. In the second chapter the author considers at length fossil anthropoids in their relations with the existing anthropoids and with man, and he arrives at the conclusion that the Hominidæ came from the *Dryopithecus* group of the Simiidæ in the late Tertiary. The fifth part is devoted to a refutation of the "heresies" and inventions (1921, pp. 91–166) that have been published in recent times by Wood Jones and Sera, also in strengthening the pure Darwinian origin [of man], although modifying it in some particulars. While he prefers to assign the origins of the Hominidæ to the northern hemisphere rather than to Africa, he considers central Asia as the point of departure for the migrations of *Pithecanthropus*, the most important date in evolution.

The task of naturalists who wish to keep in touch with anthropological questions (and they should do this by reason of their functions) is thus greatly facilitated. If we are not mistaken there is actually in progress a work of classification which will end by making

[2] From a translation of a review of Dr. Gregory's work, by V. Giuffrida-Ruggeri, late Professor of Anthropology at the University of Naples, in *Scientia*, xxxii, 1922 (October). —*Ed.*

impossible tricks and mystifications. Gregory's work is one of those which is indispensable for consultation, if one wishes to judge seriously and not on the impulse of the moment. One can easily omit or replace the anthropological appendix, although it is not without merit in so far as it is an eclectic attempt which gives the classification of human races, but according to authorities who are somewhat obsolete (Deniker, Haddon, and others).

SCIENTIFIC PROCEEDINGS

OF

DENTAL AND STOMATOLOGICAL SOCIETIES

PROCEEDINGS OF DENTAL AND STOMATOLOGICAL SOCIETIES

PUBLISHED IN INDEPENDENT SECTIONS

Each section or sub-section is entirely under the editorial autonomy of the Society it represents, within the limit of the number of pages set by agreement

PROCEEDINGS OF DENTAL AND STOMATOLOGICAL SOCIETIES

THIRD SECTION

International Association for Dental Research

Disputed points and unsolved problems in the normal and pathological histology of enamel. *J. Leon Williams*, D.D.S., L.D.S., R.C.S.I. ..... (27)
Discussion ..... (107)

Ohio State Dental Society

Mottled enamel, and other studies of normal and pathological conditions of this tissue. *J. Leon Williams*, D.D.S., L.D.S., R.C.S.I. ..... (117)

FOURTH SECTION

First District Dental Society of the State of New York

Education as a factor in the rising tide of preventive dentistry. *Frederick A. Bricker*, D.D.S. cxxxix
Discussion cxlviii
Notes on an ethical question in dental science. *Thomas J. Barrett*, A.M., D.D.S., F.A.C.D. clix
Discussion clxv
Root-canal treatment. *Edgar D. Coolidge*, D.D.S. clxvii
Discussion clxxvii

New York Academy of Dentistry

Histopathology of dental caries, and its periapical sequelae. *R. W. Leigh*, A.B., D.D.S. ..... (197)
X-ray treatment of tonsillitis and chronic pharyngitis. *W. D. Witherbee*, M.D. ... clxxxvii

American Academy of Periodontology

A study of skulls in the American Museum of Natural History in relation to periodontal disease. *Isador Hirschfeld*, D.D.S. 241

EDUCATION AS A FACTOR IN THE RISING TIDE OF PREVENTIVE DENTISTRY[1]

FREDERICK A. BRICKER, D.D.S.

Hollywood, Calif.

CONTENTS

I. Introduction cxxxix
II. Clean mouths through individual education cxliv
III. Concluding comment cxlviii
Discussion cxlviii

I. INTRODUCTION

I am very much pleased to be with you this evening. Before I go on with the paper, I would like to tell you what prompted me to write it. In Rochester, Minnesota, we have many visiting dentists, and many dentists coming with their friends and relatives for medical attention. I ask each one, "Are you talking preventive dentistry?" The answer of the majority is, "There is no use in talking to patients, telling them to keep their mouths clean, because they will not co-operate. More than that, there is no use talking to them about their health. When they are sick, they think of their physician, and they will not pay the dentist for advice." Personally I have found this to be untrue, and I can verify this statement by the testimony of many men in this audience.

Were I to remark that the hope of civilization lies in education, many of you would murmur inwardly, "Did you come all the way from Rochester to tell us that?" Yet a variation of this great truth is exactly what I wish to discuss with you. Because a truth is familiar we are too prone to cast it on the scrap-heap of the trite, and go out in quest of new ones; but some truths can never be exhausted, and are always capable of new applications to life. So it is with the one to

[1] Read at a meeting of the First District Dental Society of the State of New York at the New York Academy of Medicine, on December 12, 1922.

which I have just referred; for in preventive dentistry lies the hope of health of many an individual in this and coming generations, and its far-reaching results can only be reached through education.

Many of us have carefully sidestepped the profession whose province is bounded by blackboards, and whose proverbial purpose is "to teach the young idea how to shoot." Yet with perfect equanimity we remark that in education lies the hope of civilization. How, then, is the poor old world to become educated, especially on points regarding which the average teacher is uninformed, or ill-informed? We may not like wriggly children congregated in an atmosphere of chalk-dust, but think of the adventure of planting a young idea in an adult's head while you have him comfortably (?) seated in your dental chair, where you can keep him from objecting!—of fertilizing that idea with plaques removed from his teeth, and held coldly before his eyes; of planting the idea first in a professor's head, then in an M.D.'s, and finally in a street-laborer's, and watching it develop in these different soils. It can contain all the excitement of playing with dynamite, for ideas are dynamic—and all the disappointments of wet dynamite, because, unless properly illuminated, ideas won't go off. Moreover, the illumination will rest with *you*—how much real knowledge of preventive dentistry you have, and how much versatility in applying it.

McDonald of the *Toronto Globe* says, in a very wonderful address, "Beware when God releases an idea into the world." It may blow up old institutions and work revolutions, or it may quietly penetrate the mass of ignorance and stupidity, until the whole mass comes tumbling to the ground, and the springtime of a new world is here. Our business is not only to treat and relieve and make over, but also to *educate*, and so make our contributions to the good of the race. Young ideas about clean mouths and preventive dentistry will have vastly more to do with the direction in which the health of this and succeeding generations shoots than even we of the profession realize. One would hardly consider the instruction, "Be clean; keep clean," a matter so profound that the world would have to wait until the twentieth century for so great a man as Major General Goethals to drill it into us. Yet when we are told to clean up, we soon lazily or indifferently forget the whole lesson. Small boys in the year 1922

do not like to wash their faces, especially behind their ears, much better than they did in the time of Queen Elizabeth; our affinity for dirt is prodigious.

The work of education, whatever be the field, is so quiet and monotonous, with a constant insistence on old and familiar truths, its startling and dramatic moments are so rare, that we are tempted to lose interest or become discouraged. We must begin all over again with every new generation and teach them the A-B-C's of wholesome living. Is such a tedious task worth while? Is the possessor of a D.D.S. called upon to take it up? May he not justly content himself with making good bridges, extracting teeth, and cleaning them when presented? There is only one way to find the answer, and that is to turn to other fields where education has been subjected to the acid test of time. Look at Japan with its whole life made over in three generations. Consider the Philippine Islands with life vastly changed even in one generation by the grace of the teacher, of education, of ideas, of example. The whole world of medicine was penetrated and transformed by the teachings of Pasteur, the centenary of whose birth we celebrate this year. Only a decade ago, a child's reader contained the following:

Baby Bye
Here's a fly
We will catch him, you and I.
How he crawls
Up the walls,
Yet he never falls!
I believe with six such legs
You and I could walk on eggs.
There he goes
On his toes
Tickling baby's nose.

What a contrast to our present day attitude, with our fly-swatting campaigns, crusades against possible breeding places, and education of the public regarding the disease-carrying propensities of this self-same fly! Through education of the public, there has been no epidemic of yellow fever since 1905. In the Canal Zone, deaths from malaria were reduced about 85 per cent in less than four years. So progress is made. The world does learn. The climb is upward.

The inheritance of knowledge, ideas and habit does count; and in the light of what has been attained, we should feel inspired to greater effort in teaching preventive measures. The object of these, as of all other education pertaining to health, is to equip the individual for a better fight for existence.

Edison has said, "The greatest things are the simplest and the last to be discovered." When we realize that only from 15 to 20 per cent of the people in this country give their mouths any serious consideration or care, we know there must be a reason. There are three principal reasons: ignorance, indifference, and poverty; but ignorance and indifference are the important ones. How shall we attack this great mass of ignorance? Here lies the work for years to come, for the dental and medical profession. It is the duty of the physician, as well as the dentist, to be well-informed and thoroughly conversant with the teachings of oral hygiene. If every dentist and physician can be converted to the gospel of oral hygiene, the layman will not long remain ignorant. Joseph Ford Newton says "the great American sin is a kind of half-humorous, good-natured indifference." This applies to the profession as well as to the laity. Trace most of our ills to their source, and it will be found that they exist by virtue of an easy-going, fatalistic indifference, which dislikes to have its comfort disturbed.

There are four steps leading to every achievement: First, attract attention; second, arouse interest; third, create desire; fourth, act. That the laity is becoming interested in cleanliness of the mouth is evidenced by articles on this subject in many popular magazines. This proves that we are on the second round of success. People get what they want if it is within reach of effort. If you will investigate the per capita investment in automobiles, fine clothes, and other luxuries, you will get some idea of how people spend their money for the things they want. If they can be made to desire clean mouths as intensely as they desire luxuries, they will get them. Before prevention can be successfully taught in the schools, each dentist must do his share by instructing his individual patient. Thus is a nucleus formed, which in time enlarges in the community until, through public demand, a school-board in sympathy with these measures makes this teaching a regular part of the curriculum. Even

in the advanced cities where such instruction is already given, the dentist has much to do individually with those who went through the schools before these enlightened days.

There was a time when dentistry meant little beyond extracting teeth. Later, restoration of teeth became an important factor, and it remains for us to lift preventive measures to their rightful place. Briefly the position is this: on the one hand we possess, as the result of scientific research, a large mass of accumulated knowledge in dentistry, dealing with the nature and causation of disease. On the other hand, there are a great number of people who, in their ignorance, become victims of avoidable disease. We all agree that a clean mouth and proper diet are the first steps on the road to good health, but the pace of a snail is swift beside our progress toward *unity* in imparting this information to our patients.

We must, of necessity, develop and adopt systems and methods of practice which are suitable to the needs and possibilities of the masses. We must develop a technique that will be capable of application, and which will produce results and be taught and practiced by every progressive dentist. Such a dentist should have an authentic and fundamental knowledge of preventive dentistry. His position is that of an advisor, his duties are to prevent, correct, and improve conditions that affect general health and react upon it. He must know much more than he needs to impart, and he must believe in the truth of his teaching, if he is to draw a picture sufficiently vivid to arouse the interest of his patient. "Nothing is so disarming, nothing so compelling, as the whole truth plainly and sincerely told," says a present day writer. Before we can convince our patient of the necessity of a clean mouth, we must prove to him that there are dangers in an unclean one. I am going to describe my own method; but to deny that there is room for variation of the details to suit your needs, in arriving at the same result, would be to discredit your individuality.

First, take the case history and make a roentgenogram of the whole mouth. Make a careful clinical examination of the mouth with the assistance of the roentgenograms. At this point I determine the etiologic factors in the case, with regard to caries, deposits, and periclasia. Before we can hope for the coöperation of the patient, we must

explain the cause of these conditions and the logic of the treatment in such a clear and simple manner that the patient can grasp them.

II. CLEAN MOUTHS THROUGH INDIVIDUAL EDUCATION

Teach your patient the causes and prevention of decay and periodontal disease, might well become the slogan of the dentist of this generation. Regard the patient as an intelligent being and teach him as definitely as you would like to be taught; do not cover the subject with three meagre words: "Brush your teeth." The following suggestions as to what the patient needs to know, and the method of teaching him, are offered as the result of experiment and experience with hundreds of my patients since I first became interested in this phase of dentistry.

There are six things which he particularly needs to know: First, the causes of decay; second, the causes of periclasia; third, that decay and periclasia can be prevented by proper hygiene and diet, and by regular visits to the dentist; fourth, that teeth will not stay healthy without care; that although the dentist can, at times, restore them to health, the patient must keep them healthy; fifth, that the oral cavity is the seat of more focal infection than any other part of the body, and its available area for infection greater; sixth, the fundamentals of diet as affecting teeth. Let us consider these in turn.

(1) *The causes of decay, and periodontal disease.* These can effectively be brought home to the patient by staining the surfaces of the teeth with a disclosing solution, so that he can see the bacterial plaques. Then let him examine his teeth with the aid of a mirror. Explain to him the action of bacterial plaques in forming acids which disintegrate the enamel, and tell him that deposits are formed by allowing these same plaques to remain on the teeth.

(2) *The causes of periclasia.* Explain to the patient that the principal cause of periclasia, commonly called pyorrhea, in younger patients (18 to 30) is lack of proper care; and later in life, the abnormal occlusal wearing of the teeth, and the use of the harder golds employed in restorations, which produces traumatic occlusion. Loss of teeth, and inaccurate, unfinished, and unhygienic restorations are also factors of periclasia in the adult.

(3) *Prevention of decay and periclasia.* Demonstrate that these

conditions can be prevented by proper hygiene of the mouth and suitable diet, and by regular visits to the dentist.

(4) *Coöperation of the patient.* Make plain to the patient that "to cure" means merely to restore to health, not to make immune; and, therefore, that the permanent result depends upon his daily efforts much more than on the occasional efforts of the dentist. Show him that not merely daily efforts, but also conscientious, thorough-going efforts in tooth-brushing as in business-building will acquire the result desired; that the question is not only "How often do you brush your teeth," but "How well do you brush them."

(5) *The mouth a seat of infection.* Many patients realize that the mouth is a seat of infection, but few realize that the oral cavity is the seat of more focal infection than any other part of the body. Show your patient how large an area is available for infection here.

(6) *Fundamentals of diet as affecting teeth.* "What has diet to do with teeth!" is so common an exclamation that it is important to explain that the mastication of coarse foods, such as whole wheat breads, vegetables, and fruits, is essential to the maintenance of a healthy mouth, inasmuch as this mastication provides a natural massage for the gums and teeth. You know this, of course, but your patient does not. Tell him.

With many patients these six truths will be sufficient; but, in the face of continued indifference, which I have found rare, it is effective to remark that an unclean mouth is the predisposing cause of such disease as anemia, arthritis, nephritis, cystitis, myocarditis, iritis, appendicitis, encephalitis, gastric, and duodenal ulcers. As a profession we take too much for granted; we should take nothing for granted. There is no more reason for us to assume that a learned theologian ought to be well-informed on preventive dentistry than for the theologian, our patient, to assume that we are well-informed on theology. We are all most interested in the other fellow's job, the thing we do not know about, or are not tired of; therefore, all the rest of the world is interested in preventive dentistry, if we will only inform them.

As a rule the educated person does not know the location of the attack of decay any more than the uneducated; therefore, he does not know how to reach these surfaces unless he has been taught.

This was forced upon my attention recently, and because the illustration is so graphic I venture to quote two cases.

Case 1. A very prominent physician came by appointment. The assistant placed a glass of saline solution, containing a mouth brush, on the bracket table. Mr. Physician scrutinized the glass very carefully and then remarked, "What are you going to do with that?" "I am going to brush your mouth," I replied. "Doctor, I brush my teeth from three to five minutes every night and morning," he protested. "That is enough if you do it right," I said. Then, applying a disclosing stain to his teeth, I gave him a mirror to enable him to see the location of the plaque and with an instrument I removed a portion of it from the mesial surface, close to the buccal angle and gingiva of the upper left first molar, and showed it to him. With a surprised expression on his face, he asked, "How shall I brush to remove that?" This was just the opening I had been waiting for, and I proceeded to demonstrate to him how to brush his teeth so that he would know by the sense of touch when he was doing it correctly. Next, I told him the cause and result of these plaques. "Now, isn't it strange that my dentist never told me this before," he exclaimed.

Case 2. This patient is a day-laborer, and has only a very limited education. He had never used a mouth brush. "How anxious are you about saving your teeth?" I asked. "Well, I will do anything to save them." "Would you brush your mouth in the way I will teach you, for five minutes at night just before retiring and five minutes in the morning upon arising, for the rest of your life, or as long as you wish to retain your teeth? If you will do this, I advise treatment; if not, treatment will be useless." "If you teach me how to do it, I will, if that is the only way I can save my teeth." I proceeded as I had with *Case 1*, giving the patient a reason for each effort and an object to attain. Curiously enough, when I had finished, he asked the same question as the physician. "Why hasn't any dentist told me about this before?"

He has continued conscientiously brushing his mouth for the past three years. In both of these cases the results have been very gratifying. Chance could not have given me two patients, differing more widely in social position. In one, interest was gained primarily

through the aesthetic and scientific sense; in the other, through the purely practical sense.

Going to Chicago one evening on a Pullman, I tabulated the methods used in brushing the mouth and dentifrices used. Ten men were on the Pullman besides myself. Seven of these brushed their teeth, using a paste. Three brushed the labial and buccal surfaces of the anterior teeth, mostly the uppers. Three brushed on the labial buccal surfaces of the upper and lower teeth, and one brushed the lingual, labial and buccal surfaces of the upper and lower, but not the gums. These men were all well-groomed and above the average mentally. What results may we expect from such methods and to whom are our patients to look for information?

We all know the wonderful results that have been obtained by Doctor Fones of Bridgeport, Doctor Epling of Welch, West Virginia, Doctor Davis of Flint, Michigan, and many others, through education in the public schools; but who is planting the dynamic idea in the mind of the adult? A hundred people can be moved to action by teaching from actual demonstration, to one who receives a motor impulse from a book. Such instruction would make us a hundred fold more efficient to our community than do postgraduate courses in other branches of dentistry. No greater indictment could be brought against the dental profession than that it conceals the cause of at least 80 per cent of oral conditions. As a prominent physician remarked, "Unless the dental profession is aroused from its slumber we will annex its main pillar of support and add it to the medical foundation of preventive medicine." Our duty lies before us, exacting, imperative, inexorable. Who will measure up, and thus keep dentistry in its just position as a branch of the healing art?

Today against the detours of carelessness, the punctures of neglect, and the ravages of filth, nothing great can be accomplished in preventive dentistry without the burning earnestness and vehemence of a Roosevelt. Let us join hands with modern knowledge. After all, the world is ruled by the teacher and not by the soldier. Ideas and education are the inspiration of all real progress, and are the only guarantee for its continuance.

III. CONCLUDING COMMENT

Someone told me to-day that Dr. Hyatt said he was coming up to see Dr. Bricker's clinic, because he wanted to find out where 97 per cent of all decay began. That was a little bait I had placed in the program, so I got *one* on it, anyhow! (Laughter.) These four steps are required in every successful line of business: (1) attract attention; (2) arouse interest; (3) create desire; (4) end in action.

There is no doubt in my mind that there is more periclasia produced to-day through the use of the hard golds we are using, than ever before in dentistry. In Cincinnati, the other day, I received a card advertising gold. On the back of the card was given the wearing qualities of the gold, its malleability. You see the trend—getting a gold that wears equally with the opposing tooth. Our professor at college used to tell us, when we placed a crown, and the patient complained of its being a little high, to say, "Yes, it is a little high, but it is like a new pair of shoes; it will adjust itself"; and so it would. The gold we were using at that time was soft enough to be battered down before it had produced any serious damage to the structures surrounding the root of the tooth.

The medical men are teaching mouth hygiene in the hospitals to diabetic and gastric ulcer patients. You are going to be shocked when, in the near future, your patient replies to your suggestion of oral hygiene, "Oh yes, my physician is teaching me all about the deleterious results of an unclean mouth." We are allowing the physicians to take possession of this part of our duty, and to teach it to their patients and rightly take the credit. I said to a staff member in the Harvard Medical School, "You are appropriating the salient point of dentistry." He replied: "I admit it. We are teaching this for the benefit of the patient, because the dentist is not doing it." Yet the great majority of dentists sit still and allow the medical fraternity to seize this most important phase of dentistry and add it to the foundation of preventive medicine.

DISCUSSION

William A. Jaquette, D.D.S. (Philadelphia, Pa): It is a great pleasure to be present, to have listened to this most valuable contribution from Dr.

Bricker and to take part in the discussion of preventive dentistry, which is *the* live topic of the profession to-day. The essayist has dignified the subject by placing his presentation on the high plane of education, for it is through enlightenment that the benefits of civilization are spread. The dental profession through the individual dentist is to be the means of this enlightenment. He must first be convinced as to the absolute truth of the subject matter he presents, for without faith in that his words will be empty and hollow sounds, though he be gifted with eloquence. As the state demands a normal-school training or equivalent for the preparation of teachers in the public schools, so must the dentist prepare himself for this responsibility, which he is to assume toward his patient. How discouraging to see dentists about a prophylaxis clinic, draw their lips over their teeth to conceal their teeth. Lectures given by such dentists on the benefits of a clean mouth will not be convincing. If they really believed in such benefits they would possess them. The American Public, always practical, may be interested in the cost of the *lack* of oral hygiene—cost in pain, in ill health, in time spent in the effort to repair the damage of disease, and in the dollars paid.

Oral hygiene cannot be a separate thing, but must embrace all of hygiene. Dr. Bricker has made no attempt to enumerate all the factors in better health, but it would seem to be necessary to emphasize to all mature adults the importance of the daily water intake—fully two quarts—and exercise. It is right to say to the busiest person that seven to ten minutes daily taken from work or sleep, and spent in exercise, will result in greater and better production, whether that individual's vocation be intellectual or manual craftsmanship. Dr. Bricker would have us focus the attention of the patient on diet, both as to the elements required for structure and for proper exercise of the dental and periodontal tissues.

It is well to correct the impression that bone is a fixed tissue. It is a most plastic one, depending for its development on function. The result, then, of vigorous mastication of proper foods from childhood on is to develop strong bones and alveolar processes about the roots of the teeth, with good vascular nourishment, which will assure the highest resistance to those destructive forces, traumatic and bacterial, which hasten the onset of that sequence of symptoms, the result of which is known as pyorrhea. The dentists of Ohio, the past week, have had a unique and effective graduate course in nutrition, in relation to preventive dentistry, and will be the better teachers in consequence. In Cincinnati, an oral hygiene luncheon was served to nearly a thousand dentists at the Sinton Hotel—a protective and balanced diet, combining the ideas of McCollum and McCann.

A suburb of Philadelphia, like many communities, has established scales

in the public schools for the weighing of the pupils during the year at different periods and reporting to the parents deficiencies that suggest malnutrition. One parent, a christian scientist, received word his child was underweight, was not developing normally and that a quart of milk daily was recommended. He wrote back, that he sent his boy to school to be educated not medicated. This type of parent may be resistant or even impervious to education by the dentist or the teacher, but the child is not and will learn the truth about diet.

A patient, a member of the firm of an important advertising agency, while receiving instruction as to home care and diet in relation to preventive dentistry, was very attentive and then said, "These matters so appeal to my judgment that I believe them and wish to carry out your instructions for myself and my family." He added, "But do you know, doctor, that the mind not trained to grasping full details of an interview, will not get or will not remember all the points presented. You should have that subject matter printed." He further explained that the science of selling has developed the fact that the salient features in presenting a commodity must be repeated in *varied* form five or ten times, if it is an article requiring fifteen minutes to sell, but for an article like an automobile, requiring an average of ten days to two weeks to sell, the salient features, again repeated in *varied* form, must be presented as many as twenty-five times at the different interviews. This scientific information from a practical man of affairs should make us see the necessity of thoughtful and patient presentation of the educational propaganda committed to our care.

As a result of this hint from the advertising specialist, a home card was prepared, and one is given to each patient after his mouth has been brushed and he has received instruction as to his share of the responsibility in maintaining oral hygiene. This card is non-technical throughout.

The essayist states the educational requirements in four steps: (1) attract attention; (2) arouse interest; (3) create desire; (4) act. He then asks if the possessor of a D.D.S. is called upon to take it up. The responsibility is ours; we must meet it.

Frederick S. McKay, D.D.S. (New York City): In our pursuit of new truths that may be related to our professional life, may it not be well for us, as our essayist suggests, to give thoughtful consideration to some of the old ones. The newer ones, even after being pursued and caught, can have no more fundamental application to our problems than have these older ones, which at least have the merit of being already in captivity.

Preventive dentistry, or to use a more comprehensive phrase, the applica-

tion of dental science or knowledge against destructive processes, is a broad term, and as popularly used, has been applied chiefly to the attack of these destructive processes at their period of inception. To-night we are discussing preventive measures as applied to adults. The average adult, certainly the one in or approaching middle life, presents a sorry spectacle from the dental standpoint. It is too late to talk about prevention to a badly damaged individual. Without mentioning the actual loss of certain teeth, it is quite the exception to find a case in which a serious loss of alveolar process has not occurred about several teeth, undermining their stability, and in some cases giving appalling evidence of carious damage. Also, we find such an individual rarely established upon anything like an adequate or efficient method of daily care.

The paper does not deal in any sense with operative measures, hence I shall not depart from a strict conformity in discussing it, but I ask your permission to say just this. From the viewpoint of the essayist's attitude, I consider that for such an adult individual, no application of service or assistance compares in value with the thorough removal, with exquisite thoroughness in detail, of all apoxemena, rough margins or edges, sordic debris, and the restoration of enamel and exposed root surfaces to glistening cleanliness. Such a service should precede all reference to carious teeth, except, of course, the source of actual pain, or the restoration of lost teeth. Clearly then, the problem has become one of putting into operation measures designed to prevent further damage, and our essayist is undoubtedly correct when he maintains that the one broad open road is through education.

I will admit, with Dr. Bricker, that the iteration and reiteration of truths that are to us so obvious is almost monotonous, but is it any less so than the work of a teacher in any other subject? Did our own teachers tire of imparting the same information over and over; but had they, what of us to-day? What other way is open? It is vastly more interesting to indulge in handsome or even artistic restorations, or perform delicate mechanical manipulations, but their very need emphasizes the tremendous call for this less conspicuous and even prosaic work of teaching, emphasizing, almost imploring a more intelligent and efficient daily care of the mouth and teeth. Do our patients also at times exhibit more interest in, and is their praise more extravagant for, the restorative phase of our work than for this less obvious service?

Edison's phrase, "The greatest things are the simplest and the last to be discovered," quoted in the paper, has a peculiar application to this problem because of the fact that so small a percentage of adults in this country (15 to 20, as quoted) present evidence of an adequate care of the mouth. It

isn't that we have just discovered it, but that we have ignored it. If we admit, as we must, that this condition exists, what are the causes? Dr. Bricker suggests three. To take the last first, it isn't "poverty," because an efficient daily care is not an expensive habit, and neither are the mouths of all wealthy persons scrupulously clean; often quite the opposite. "Indifference" is a factor somewhat frequently met with and I know of no more difficult one with which to deal, but as a great cause it has little place in the reckoning. The great cause is "ignorance," and herein lies Dr. Bricker's challenge to us. Ignorance we can deal with; and, what is more, we must if we would avoid the crashing of the temple walls about our ears, as threatened by the prominent medical educator quoted in the paper. It isn't that we need to be converted to the "gospel of oral hygiene"; we have long been that; but we should adopt a definite attitude of teaching. It isn't the layman who is indifferent; it is we.

Our essayist does not intend to censure us too severely for I am sure he realizes that the broadcasting of the hygienic propaganda has markedly improved the mouth conditions of children. In the middle and upper classes (I dislike this word "upper") a diminished carious destruction is certainly apparent, but Dr. Bricker feels, as I do, that the adult has been neglected. We have perhaps felt that having come of age he was capable of taking care of himself. Must we, you ask, continue to act in a censorial capacity, and point out, speaking in the terms of the essayist, the high water mark and unwashed ears of the adult? We must! If we agree as to the necessity, it then becomes the problem of how best to reach the attention and create the desire among the adult population, and this I leave for the consideration of others. Concerning these adults with whom we come into actual professional relations, the opportunity is at hand, and in my own estimation there is no form of teaching that compares in value with that which is offered at the side of the dental chair. Such teaching spreads; at least, it filters through that particular family. It would be a matter of intense personal interest to all of us could we hear what our patients say about us, and how they repeat, at various social gatherings, what we have said to them. This is a slow method, true; but we can at least go that far.

The essayist has outlined for us his particular method of arousing the patient's attention and the after procedure, which I regard as an admirable basis upon which to build a standardized method of instruction; not that we expect each individual to do exactly the same thing in exactly the same way, but in the main it should be standardized. The very first thing that should be brought to a patient's attention is not that certain teeth have cavities of decay, not that a certain space should be filled with artificial

substitutes for the missing organs, etc., but rather that the daily care of the mouth in general is faulty, if such be the case, or that particular spots are being neglected. I regard the use of a disclosing solution as extremely valuable. As a rule it is very impressive, even shocking, to the patient. To emphasize a detail for just a moment, my preference is a saturated solution of potassium permanganate containing a few grains of boracic acid, which, the chemist tells us, acts as a mordant to "set" the stain. Its advantage over iodine is that the entire mouth can be swabbed and the stain remains until removed, whereas iodine fades out in a few moments. The stain can be removed from the soft tissues and synthetic fillings with hydrogen peroxide. In this way the agglutinous film or plaque about which most of our patients have heard, stands revealed and it is curious to observe the crestfallen air when an otherwise well groomed person becomes aware that the teeth are not really being cleaned. Such unswept areas can be demonstrated in abundance in individuals who give evidence of violent use of the tooth brush in the form of marked or even excessive destruction of tooth structure at the necks and upon the root surfaces of certain teeth; a condition heretofore erroneously considered and called, "acid erosion." The prevalence of this form of destruction is due to nothing else than our failure to substitute a definite, non-destructive method of brushing. As the paper points out, we have simply said, "Brush your teeth," but we haven't told how. A neglected adult! Why, he asks has no one ever told me this before? Has prevention a place in this mouth? Yes, a last chance. The details would make a long story, but in brief the method of daily care should be reorganized in such a way as to substitute efficiency for violence. Here, also, is the opportunity to convince the patient that the determining factor governing the lodgement of calculus at a given spot is the amount of friction that is regularly expended on that spot. A tooth surface that is subjected to friction sufficiently to sweep off the agglutinous film cannot receive nor hold a calcular deposit. A realization of this fact effectually disposes of the onset of a very high proportion of periodontal destruction.

While our attention is on this phase of the subject, I want to call attention to our great need of an exhaustive study that shall have for its object the determination of the cause and method of calcular formations. We know almost nothing of this. What is the meaning in physiology of the presence of calcium and magnesium salts in the saliva and what is the chemistry of their precipitation in the mouth? Under the subtitle of prevention of periclasia the paper mentions "unfinished and unhygienic restorations." Here are conditions thrust upon the patient against which he is positively defenseless.

On the question of diet as affecting teeth, I want to pause for just a moment to ask if we are entirely clear in our conception as to just what this relationship is, and its place in the problem of dealing with the adult? Do we mean that the erupted and fully calcified teeth, so far as the enamel is concerned, can be altered in density, or let me say in their resistance to decay (although I am not at all clear myself as to what is meant by enamel's being able to "resist" decay), by the constituents imbibed from a proper diet? This is a point upon which we should have the most accurate knowledge and the clearest conception. Or, do we mean that certain diets contribute to decay by their propensity to adhere to and ferment on tooth areas that are not subject to sufficient friction either by natural or artificial means?

I am gratified that our essayist has found the traveling clinic conducted by the Pullman Company as interesting as have I, on numerous occasions. Closely observed, this cross-section of male humanity should make it clearly evident that our admonitions to "brush the teeth" are most imperfectly carried out. And why? Because, as before stated, we, the teachers, are not specific. To change this we should advocate a definite, positive way of performing the act of brushing and should demonstrate it with a brush with our own hands in the patient's mouth. We should select for him a brush of particular size and shape, with reasons therefor. Our knowledge concerning the ingredients and efficiency of the various dentifrices should be concise, and this information should be passed to our patients with definite reasons why certain ones should be used and others discarded. Our patients should be told that frequency of brushing is not what counts but thoroughness.

In stating that "such instructions would make us a hundredfold more efficient to our community than do post-graduate courses in other branches of dentistry," is Dr. Bricker conveying a subtle suggestion to the First District Society?

Before leaving the adult I have one more suggestion for his welfare. Our operative procedures have been carefully and faithfully carried out; Dr. Bricker's suggestions to us have been put into effect to the last detail, and our patient's mouth has been transformed into a condition with which he is even more gratified than are we. How shall it be maintained? The definite thing to do is to establish a dated card-index system into which the patient's name should be placed and a definite interval for treatment decided upon. It is surprising how many patients will request such a service as this. When an individual's card "comes up" he should be sent for, inexorably and

unfailingly, and when he finds that the system actually works, the unanimity of response is remarkable. This I consider an integral part of the program for prevention in the adult.

In closing I can only commend most heartily the recommendations that our essayist has so earnestly set forth and bespeak your coöperation, that our adult patients may receive this service in more liberal measure.

A. H. Merritt, D.D.S., F.A.C.D. (*New York City*): I think, if any emphasis were needed, that the old saying, that ignorance is the curse of God, and knowledge the wings whereby we fly to heaven, is embodied in the paper Dr. Bricker has given us to-night. I was one of the thousand who stood in the hotel in Cincinnati, and saw the tremendous enthusiasm manifested on the part of everyone present—dentist, physician, educator, public worker, nurse and child—in the interests of oral hygiene and preventive dentistry. I think one of the mistakes that we as a profession have been making, and perhaps have made here to-night, is our confusion of oral hygiene with preventive dentistry. Oral hygiene is only one of the avenues by which we can hope to reach preventive dentistry. To my mind it is not the most efficient road. Preventive dentistry cannot be applied successfully to the adult.

Dr. Bricker has brought to us the problem of the adult, as applied to preventive dentistry, and he has emphasized the educational side, and the oral hygienic side; but preventive dentistry cannot come in that way. If we are interested in making preventive dentistry a factor in the life of the human race, we must begin with the unborn child. I have become more and more convinced that diet will play the controlling factor in preventive dentistry. Not only must the child take in its food the elements which are essential to the upbuilding of the teeth, because nutrition is, after all, a chemical problem plus a biological one, but the proper food when taken must be properly masticated.

I believe there is nothing that the dental profession can engage in, that is more important than educating the patients as we meet them in our offices. In no way can we do that so successfully as by an adequate demonstration to each individual. It is amazing how many intelligent people tell you that they brush their teeth so often and so long, yet their mouths are filthy. I saw to-day a fine specimen of American manhood, whose mouth was so unspeakably nasty, that I cannot designate it in any other way. That man, who has spent all of this adult life in the manufacture and sale of tooth brushes, did not know the A-B-C's of the use of the brush;

and no one is responsible for it except that man's dentist. When I called his attention to it, he asked the question which was asked to-night in the paper: "Why has not someone told me before?"

I am glad Dr. McKay called attention to the operative side. There is a triple alliance in preventive dentistry. I believe the first is diet, the second oral hygiene, and the third, the best kind of reparative dentistry which can be given.

Dr. Bricker (*in conclusion*): In answer to the question, How to obtain coöperation, I find the easiest solution is to place all the blame on the patient. I often remark that this is one phase of dentistry we can practice and still be Christians. We can always tell the truth, and place the blame where it belongs—on the patient. We can say, "If you do not coöperate, I will be glad to have you come back and I will treat you again but when you come back, I will be more experienced in this line, and it may cost you a little more. I will be glad to treat you, but do not make any complaints on the fee, because it is your problem through neglect." I have yet to see a patient who did not improve, although I have had one complaint, since I have been in Rochester. I had treated the patient's mouth about eight months previous to this incident. She returned and said, "Doctor, my gums are bleeding again; I think I have pyorrhea, and I am discouraged. I have tried to take care of my mouth, but without result." I did not look into her mouth, but asked, "Are you brushing your mouth as you promised, when you left here?" "I am brushing my mouth religiously," she replied. "I do not know what religiously means, when applied to brushing the mouth," I said, "but I am going to stain your teeth again, and wherever the bristles of the brush are not reaching, you will find a stain." I applied the stain and handed her the mirror. She colored a trifle and said, "Doctor, if you will give me another chance, I think I can do better." I saw her a few days later and she was delighted with the improvement.

Most of the patients come in smiling, and say they lost their tooth brushes, or something of the sort, and if I will only treat them and bring them back to health, they will try to do better. Few of us realize that we are supposed to be teachers; and if we do not teach, of course we cannot expect coöperation. I asked three hundred patients if they had ever had any instruction as to the cause of decay, plaques, or periclasia, and brushing of the mouth. Less than 2 per cent had any instruction, and they had merely been told to brush their teeth.

Dr. Merritt is right: "the proper time to begin is before the child is born."

I put the question to a United States senator, "Why do you gentlemen in Washington appropriate so much money for the investigation of disease in horses, cattle, etc., and so little for humanity." "Who are 'we gentlemen'?" "You are the gentlemen who make the laws." "Well," said he, "who puts us there?" "The community," I answered. "Yes the majority of the community, and we do the things that the majority of the community wants." He further said, "I would suggest to you to create a little sentiment in your community, and educate the people; they will elect the men you want to go to Washington, and you will get what you want." "Excuse me for mentioning it, I think you are correct," I replied.

Put this up to the patient; if you never teach him anything else, at least give him this thought. After the mouth is restored to health he must maintain the condition; he must keep his mouth clean. It is not the dentifrice, but the friction of the brush, which stimulates circulation; and the foundation of health is good circulation.

6381 Hollywood Blvd., Hollywood, Calif.

NOTES ON AN ETHICAL QUESTION IN DENTAL SCIENCE[1]

THOMAS J. BARRETT, A.M., D.D.S., F.A.C.D.[2]

Worcester, Mass.

It is a high privilege as well as a great pleasure to be invited to address this assembly of distinguished leaders in our profession. When I was approached through the mail, and requested to read a paper on ethics, I promptly declined, and said I could not give the time to it—that it was a subject I did not care to take hold of because I do not believe I am adapted for the role of preacher or censor. However, the present need for a word on this important phase of our professional life was stressed and I consented to go on record—and I am pleased to be here.

Our department of health service is daily growing more important in its agency for the betterment of human life, both by the enlarged efficiency of its scientific training and consequent achievements, and by the higher appraisal placed upon our serviceableness both by our patients for their individual needs, and by medical leaders in their generous coöperation towards the activities that make for the public welfare. "Nobility has obligations" was the adage of chivalry in the royal courts of olden days, and we of to-day unhesitatingly adopt that maxim in the profession of a service we give in the larger court of the world, in the unlimited territory of human welfare. It is in proof of this very assertion that I have been invited to offer some observations and criticism upon an evil that is being practiced by some unprincipled practitioners in our profession.

The insistent call to a strict regard for professional ethics and for a maintenance of our own special code of ethics has not been heeded, and I believe we should make our challenge more imperative, to reassert our loyalty to the sane and salutary principles which, in union

[1] Read at a meeting of the First District Dental Society of the State of New York at the New York Academy of Medicine, October 1, 1923.

[2] President of the Dental Educational Council of America.

with our scientific skill, we profess. However, before we come to lay the branding finger of scorn directly on particular wrong-doing, let us pause to consider some preliminary truths which give a base, as it were, for authoritative pronouncement in protest and condemnation of this growing evil that has of late appeared. For it is not sufficient to meet this evil with opinions out of sentiment or merely to deprecate it as dishonorable. True it is that the healthy sentiment of the world is against it, and likewise honor among men deems it reprobate; but there is even a deeper and more vigorous base upon which we stand in our adherence to high principles. The base is justice, the supreme virtue of our entire social order, the hinge upon which swing all true relations of man to man, the eternal foundation of all obligation, the ground even out of which grows that special Code of Ethics adopted by our American Dental Association; it is the North Star in the great firmament of rights and duties among men.

With regard to our rights in that profession which is our service and our reward, we need not emphasize words. All the world and all the varied phases of life and endeavor are alert to know the full measure of their rights; ninety per cent of the rhetoric of the platform and the press is devoted to an insistence on rights. How small is the champion who proclaims the necessity of a fearless and loyal regard for duties! Our best impulses applaud him, however, when he appears; and we wish him success. With pardonable pride, however, we, as devoted servants in our profession and as earnest members of the American Dental Association, may glance at our bill of rights. It is filled with worthy utterances.

One of our rights is the kindly esteem which we enjoy among men for the skill of our service and the dignity of our calling. Again in the matter of financial reward—the compensation for our work. It is worthy of note that language has specified it with a distinguished word. We speak of "wages" as due to common laborers, of "salary" as paid to people in an official service, but for those in the high professions, in the Sciences devoted to the alleviation of disease and the improvement of health, of which dentistry is a part, the traditional word for the payment is the "honorary," or in its accepted Latin name, "honorarium," which of late we of this country simplify with the word compensation, or fee. These two items alone, namely, the

honor in which mankind established every branch of the healing art and the *honorarium* with which they meet our services, are here sufficient to name in our bill of rights. They emphasize adequately enough for us as men of honor, and scientists of skilled training, the compelling force of that old adage, *Noblesse oblige*.

One's profession has its obligations, and therefore, as we have a laudable pride in enumerating rights, we read with the same searching eye the argument with regard to our duties. Here, too, we base our doctrine not upon mere passing whims of sentiment, nor upon honor alone, nor upon the expediency of policy nor the evasiveness of human respect, but rather upon principles that are the accepted verities of the world, eternal in their duration and universal in their application. Again we stand, from our point of view, upon the firm foundation of justice: there we scan the motive power that guides and exhorts man (and I mean men of a high profession) towards the recognition and fulfilment of his duties. For man with his rational nature is guided in all his intellectual activities, his researches, his means of livelihood, by the dictates of reason. It is the principle of justice, by which we render to every man what is his due, his right, that underlies all our obligations, and consequently, the loyal and noble pursuit of that principle is capable of exalting every worker, whatever be his chosen sphere. Our duties as men of a particular science stand clearly before us as signposts on a road; for as men we are part of the great human family, we are actuated by a spirit of brotherly helpfulness, and in our ears since childhood have rung the words of the Golden Rule. As citizens of our great country, we also recognize the call of duty and give our contribution to the common good, even in the spirit of magnanimous sacrifice to achieve our program for the welfare of the nation.

With these observations out of general ethics, I now pass to the second part of my discussion—the special considerations that rise before our present convention. The high plane of ethical standards that has been reached in the conduct of the dental educational institutions of this country is such that I feel it a duty to make a brief reference to it here. The survey and inspection of the dental educational institutions by the Carnegie Foundation for the Advancement of Teaching, aided by the Dental Educational Council of America,

has not yet been completed, but to my mind it is the greatest piece of constructive work that has ever been done for dentistry; and we owe much to the Foundation and its able representative, Dr. Wm. J. Gies, under whose direction this survey has been conducted. The widespread influence of the fairness of, and the necessity for the corrective standards inaugurated by, the Dental Educational Council, as a result of this survey and inspection, has reached the inner sanctums of every dental educational institution in this country. They have been universally adopted; and let it be said, in justice to the Deans and Executive Authorities in charge of the various schools, that they have coöperated with the Council to the best of their ability and to the extent and limit of their resources. They have brought about improved methods and higher standards. No longer have we haphazard conditions for which to apologize. Beneficial results are already noted and felt right here in this great city; and it is the hope of many of the men who have engaged in this constructive and purifying work that there will arise here in this metropolis, under the guiding influence of your great universities, schools of dentistry that will develop and send out men fit for rendering an intelligent and honest service to the people, the highest type of dentist that the world has ever known. You have everything with which to do this, if you will but show your interest and lend a helping hand. Throughout this country there is an aroused interest, and all who are familiar with the results accomplished to date believe that they will not only parallel but will exceed in importance the benefits that accrued to medical education following a similar survey by the Carnegie Foundation under the guiding hand of Flexner.

Dentistry as a profession is yet young—not a hundred years of history behind it—yet these years are filled with glorious records of progress and achievement. Men of sterling worth and character have contributed in a quiet, forceful way to its progress and standing. To-day its place among the honored professions is recognized and secure. We hold, and will to a great extent shape, its destiny and future progress, and we are charged with a duty,—yes, an obligation, to uphold the honorable traditions and to aid in its highest development. The progress of dental science has been closely watched and sternly judged. Recognition of this progress has been slow and in

some quarters it is still denied its worth and value to humanity; but of late in all well regulated and well informed health centres, it has come to be fully recognized and today the advice and coöperation of the dental practitioner is not only desired but demanded.

The recognition by the medical profession of the importance of oral sepsis, the sudden realization on the part of medical leaders of the necessity for close coöperation with the dental practitioner to make possible the practical application of the principles of oral sepsis, the revelations of the hidden areas of infection about the jaws by the x-ray, and many other scientific and surgical advances, have all been forceful factors in bringing in the new era of dentistry. This closer relationship has developed and made necessary frequent consultations between dental and medical men; reference of patients to various specialists is an every-day occurrence in the busy man's practice; and the patient, having an abiding faith and unlimited confidence in his dental or medical advisor, accepts the situation as it is unfolded to him and goes without question to the specialist selected. That this type of case appears daily in our practice is the experience of nearly every one of us. It is not an uncommon occurrence to find complications that require for final diagnosis and treatment the most searching and thorough examination of the patient at the hands of two, three, yes, even a greater number of specialists. No physical examination of a patient today is accepted or regarded as complete and final that does not include an examination and report on the condition of the oral cavity and the teeth. The enlightened public knows this and accepts the new order of things with a feeling of satisfaction. This gives to the charlatan and the dishonest practitioner an opportunity to prey upon his patients.

It is right and proper that we should honor our profession, protect one another and defend any who are unjustly attacked. No profession should be condemned for the exceptional conduct of a few of its members. Nevertheless, in our modern world the dishonest acts of men receive wider publicity than the good. Hence, if the story were once told to the public of the dishonest practice of fee-splitting, need I point out to you the condemnation of us all that would follow? There is no place where sincerity, probity, and the approval of conscience are more necessary than in dealing with the patient who has

shown his confidence in you by placing his health and physical well-being in your hands. Some men may attempt to justify this practice in a special case, but I feel sure that public opinion would overwhelm and crush them. Is our scientific progress and its wide recognition for usefulness and humanity to be now used to our detriment by a few in our profession?

The corruption of the best is the worst corruption; the higher the character and the promise of one's profession, the more debased and debasing is the lie of conduct against it. This observation comes readily to any man who takes his point of view from the high plane of our professional rights and duties. I trust we are not exaggerating the wide prevalence of this evil when we call it a system. It has, if not an organization, at least a large and growing set of camp-followers whose methods are in a way concealed under secret jobbery, under their own marking form of hood and mantle. Yet it has not been allowed to proceed in its wicked growth without comment and condemnation from those in our ranks who value the rights of our fellowmen, and our own pride in the good name of our vocation. This tree of evil was attacked in root and branch just one year ago, when in a trenchant editorial by Dr. C. N. Johnson (*Journal of the American Dental Association*, Oct. 2, 1922), it was described as "wrong in principle and pernicious in practice," "a vice to be stamped out of our professional activities."

Acceptance of a "split fee" seduces the practitioner into decisions that are made primarily for his own benefit instead of primarily for the benefit of the patient. Acceptance of "split fees" fosters not only selfishness and hypocrisy, but also rank robbery and foul play. It is unsportsmanlike because it is unfair; it is unprofessional because it is primarily selfish; it is unsocial because it imposes grossly on the trust that the public reposes in the dental profession; and it is unethical because its spirit is mean and its consequences are degrading. The man who utters approval of our standards of ethics, and does not live up to them, is to be condemned more than the man who listens and applauds the utterance of those sentiments and then goes out and violates them.

It has been said by some wise man that no gentleman needs a code of ethics and that no code of ethics will make a gentleman out of a crook.

DISCUSSION

E. L. Keyes, M.D. (New York City): I have been delighted, as I am sure you have been, to hear the fine, round phrases in which your speaker was able to make clear to you, and to denounce, the practice of fee-splitting. I cannot add materially to his exposition of the subject, yet I cannot refrain from urging you to read several times, as I myself have read several times with interest and profit, the report of your committee on this subject, which forms part of the program of to-day's proceedings. They have most admirably covered the ethical aspect of the situation. I entirely agree with the speaker, that no code of ethics will make a gentleman out of a crook. Yet I feel that, as the result of such a movement as is now afoot in your branch of the medical profession (as indeed it is in all the others, thanks largely to the American College of Surgeons), you will be able to point out so insistently to a moderate crook that he is a crook, that it gradually will discourage him.

The code of ethics to-day is substantially the same as the code of ethics of all times, but the necessity for denouncing fee-splitting has only recently arisen in your branch of the profession, as in mine. Yet to illustrate how little the profession of medicine has changed in the past fifty years, I cannot do better than to state an aphorism of Dr. Van Buren's, whose picture you see upon the wall in this room, and who was my father's preceptor. Dr. Van Buren used to say that you need to know three things in the practice of medicine: you need to know how to diagnose a case; you need to know how to guess the prognosis; and you need to know what to charge your patient. In the essence of things, those are the only three things you need to know to-day, to practice dentistry or any other branch of the profession. By making a correct diagnosis, a correct prognosis, and charging the patient the exact fee he expected to pay, or perhaps two dollars more, you will make an impression that will make that patient yours for life.

The most important thing that the patient demands is that you tell him the truth. That is the only thing a patient absolutely demands of his medical advisor. The patient does not know what is the trouble or whether you must pull out the tooth that causes the trouble, but he puts that all in your hands, and he expects you to tell him the truth. If you do not, you are a crook; and one of the ways of the crook is to take money for sending a

patient to a practitioner, not because of his qualifications, but because he pays you a fee in return, which fee is not known to the patient. I think the legality of the thing is perfectly expressed in the saying that fee-splitting is entirely unacknowledged. One does not say:—"I will send you to this man because of an agreement whereby I get five per cent of the fee." Not even a crook will say that; but if you follow that practice, you are not an ethical practitioner.

This recent attack on fee-splitting is something that has become necessary in order to hold it up before people who are tempted to become crooks, and to force a large number to see the point and cease to be crooks. I am sure the effect of such a meeting as this will be much wider than that of any number of trials of men who are caught, not because they are crooks, but because they are clumsy crooks. There are any number of crooks whom you know to be crooks, but you merely avoid them, and let it rest there. At this meeting you are letting them know what you think of them.

ROOT-CANAL TREATMENT[1]

EDGAR D. COOLIDGE, D.D.S.

Chicago, Ill.

CONTENTS

I. Introduction clxvii
II. Value of case histories clxix
III. Diagnosis of pulp and periapical conditions clxix
IV. Pulp removal clxx
V. Multiple foramina clxxi
VI. Method of pulp removal as a cause of periapical pathology clxxii
VII. Root-canal treatment clxxiii
VIII. Pulpless teeth clxxiv
IX. Summary clxxv
Discussion clxxvii

I. INTRODUCTION

The attitude of the profession in regard to the treatment of root canals, ranging all the way from vital pulp removal to the final extreme of abscess treatment, has evolved through doubt and uncertainty to a period that seems favorable for progress in this line of work. The interest now being shown is prompted by a wide-spread and genuine desire to save teeth. Because of the destructive practice of extracting all pulpless teeth, which has been more or less common in recent years, study and research have been stimulated in pulp and peridental membrane histology, to counteract such a needless and ruthless sacrifice of useful teeth. Careful technique and aseptic methods have proved that a large percentage of root-canal treatments are successful. Some of the root-canal treatment of the past shows up so well that it is convincing evidence that careful technique has always been rewarded with a high degree of success. In an address before the Illinois State Dental meeting of 1922, Dr. Edmund Noyes (9) reported a review of the root-canal filling of fifty years of his prac-

[1] Read at a meeting of the Pathodontia Section of the First District Dental Society of the State of New York, at the New York Academy of Medicine, on October 25, 1923.

tice, and about 70 per cent of the cases he was able to find showed radiographic evidence of healthy periapical tissue. Dr. Noyes is one of those painstaking operators who have always followed the straight and narrow path, and have not sought short-cut methods of operating. There is little doubt that the disrepute which root-canal treatment has suffered is largely due to failures resulting from a lack of care in operative details. There is no doubt that the use of certain drugs has caused some of the trouble, and lack of asepsis in operating has been generally accepted as the most common cause for periapical infections. The record of the filling that was placed in a root canal twenty-five years ago can furnish us with some very helpful information, if we will study the details of treatment and compare them with what we are doing today. The methods of operating which have proved successful can be duplicated today and we can also correct some of the mistakes of the past.

The histological characteristics of the cementum and the peridental membrane are far better understood today, and there is a clearer comprehension of the way these tissues react to irritation. Considerable study has been devoted to the changes taking place in these tissues following some of our treatments, from which a better and more reliable technique has been evolved. Research by such men as Noyes, Thomas, Hatton, Skillen, Grove, Talbot, Box, and others, is clearing up many of the clinical problems that have been encountered.

The test of the success of a root-canal filling is that the root will withstand the critical examination and scrutiny of our dental confreres, and the physician, or those engaged in any branch of the healing art, without being condemned as a source of infection because of the evidence of pathology, observed by radiogram, existing about the apical area. A root surrounded by healthy tissue cannot be pronounced a menace to the health of the individual in whose mouth it may be found. Radiographic examination and interpretation is not a truly exact science. There is great variation in radiographic evidence as generally furnished and not until several radiograms, taken from different angles, of doubtful areas have been studied, can an accurate diagnosis be made. The interpretation of radiographic evidence is also subject to a certain latitude of variation. One diagnostician may consider slight periapical-tissue change as an infected

area and a menace to the general health of the individual without any consideration of the case history, while another may go to the opposite extreme and overlook dangerous areas.

II. VALUE OF CASE HISTORIES

There are three classes into which roots showing periapical changes may be placed. First, those showing large radiolucent areas where there is considerable bone involvement, with the apex of the root projecting into the cavity, which all would condemn for extraction. Second, those cases showing slight tissue change, with very little loss of bone. Third, the borderline cases which show some evidence of bone involvement of an indistinct outline. If case histories were available for each root-canal filling, showing a complete record of the treatment preceding the canal filling, the radiographs showing the condition of the periapical tissue before and after treatment, they would help greatly in determining more accurately the causes of the pathologic areas found today about the roots of teeth. Quite frequently a radiograph will show periapical tissue changes taking place before pulp removal. If such areas do not clear up after treatment, it does not reflect as much discredit on the operator as when changes take place where the condition was perfectly normal before operating upon the pulp. A reference to the history in such border-line cases is of value in the diagnosis, as it may prevent a useful tooth from being condemned too hastily. A frequent survey of one's root-canal fillings over a period of years, made by radiographic examination, is of great benefit to the operator. One should study the history of both the successful and the unsuccessful cases.

III. DIAGNOSIS OF PULP AND PERIAPICAL CONDITIONS

It has been of considerable help to the writer to follow a very brief classification of the conditions of the pulp and periapical tissue. Of the teeth containing pulps only four conditions are classified. It is desirable to keep a classification as simple as possible where one is called upon to use it in a busy practice.

1. Condition of pulp
   (a) Normal
   (b) Hyperemia or inflammation

(c) Exposed by caries
(d) Gangrene
2. Pulpless tooth
(a) Dead pulp
(b) Previous root filling
3. Condition of periapical tissue
(a) Normal
(b) Acute abscess
(c) Granuloma
(d) Liquefaction necrosis
(e) Infection cyst

When the examination is made the classification is recorded upon a form suggested by Dr. Arthur D. Black for the pulp-case history (1). The history when complete will contain all information in regard to diagnosis, the date of every treatment and the drugs used, the method of sealing the tooth, the root canal filling and a blank space for subsequent examination records by radiograph. This blank form is printed on the outside of an envelope which is filled in after each operation, and the measuring wires, radiograms and all other records of the case are kept and filed. The case history becomes more valuable as time passes, and as subsequent examinations are made to determine the condition of the periapical bone and soft tissue.

IV. PULP REMOVAL

Pulp removal is often necessary. It is far better to remove a diseased pulp than to have it die under some mechanical restoration, and better to remove one that is exposed than to attempt pulp capping. Pulp capping is principally indicated for children before fifteen years of age. It may be tried in favorable adult cases of very near exposure or slight exposure, but is usually found unsuccessful.

The radiogram of a root containing a diseased pulp will often show that the periapical tissue is already involved in some pathologic change, while the pulp still reacts to the vitality tests. After carefully removing the pulp and filling the canal with care in every detail of the operation not to injure the periapical tissue, there may still be present a condition that any other operator or diagnostician would suspect. We may not feel assured that such an area is not infected but at least we may feel certain that this pathological area was not directly or indirectly caused by the treatment of the root canal. A radiogram

should always be taken before beginning to operate upon any canal. Dr. Carl Grove has stated (6) that "our present technique of pulp removal has failed to prevent periapical infection because this tissue has not been preserved and not because we failed to make perfect fillings." This statement, backed up by his beautiful histological sections, furnishes convincing evidence that it is not so important to have the root canal so well filled that there is some protrusion of the gutta-percha as it is to avoid injury of the tissue beyond the foramen.

The reports from the histologists have shown us that the peridental membrane reaches up into the foramen of the root and that the pulp tissue begins at the dento-cemental junction, which may be quite a distance from what appears in a radiogram to be the apex of the root. Grove also states (7) that all pulp tissue should be removed without injury to the apical tissue, so that the cementoblasts lining the foramen may continue to function and gradually narrow down the diameter of the cemental foramen to its final closure after the completion of the root canal filling.

V. MULTIPLE FORAMINA

In pulp removal what shall be done with the many branches of the canals and the multiple foramina? At first thought one might easily be discouraged and decide that complete pulp removal is impossible and consequently the success of the operation is hopeless. The canal fillings that were put in before much was thought of multiple foramina have proved successful in many cases. Many partially filled canals have stood the test of time and it would seem that too much importance has been attached to the filling of multiple formina, as stated by Hatton (8). It will be found by looking over current literature that the question of multiple foramina has been overworked. All foramina are formed by cementum and are consequently lined with cementoblasts, while the pulp tissue lies within the dentin (11). As the pulp tissue is removed from the root, the blood vessels and nerve tissue lying within these small openings through the cementum are gradually closed by nature in a way that completely obliterates them, if they are not injured during pulp removal by mechanical or chemical means or by bacterial invasion. This fact seems to be a reasonable argument against the use of arsenic or other caustic drugs

in devitalization and removal of the pulp. The periapical tissue is very susceptible to injury and to consequent inflammatory reaction. More often injury results from an attempt to fill multiple canals than from infection through them, where the main canal is thoroughly cleaned and filled to the dento-cemental junction. Noyes says (10) that he "can see very little difference as to whether you have one opening at the end of a root or three or four, as far as the technic is concerned." New layers of cementum are laid down upon the surface of the root as long as a healthy tissue exists about the root, but not if the attachment of peridental fibers to cementum is interfered with by drugs or mechanical injury of any kind.

The consideration of most importance in pulp removal and in all root canal treatment is to preserve a healthy periapical tissue that will continue to function. New layers of cementum must be laid down to support the attachment of pericemental tissue. Partial pulp removal, injurious drug treatment, mechanical injury, and infection, must be guarded against as causes of periapical changes subsequently found by radiogram. The method of pulp removal has been found to be one of the causes of injury to the periapical tissue.

VI. METHOD OF PULP REMOVAL AS A CAUSE OF PERIAPICAL PATHOLOGY

In checking up our records of pulp removal by means of cocain pressure anesthesia (3 and 4), it was found that the radiograms of many cases showed areas of periapical-tissue change, some appearing immediately after root filling and others in a few months. These radiolucent areas vary from small dark lines over the apex of the root to larger areas including some bone absorption. Careful study of these cases revealed the fact that, where the pulps were exposed or nearly exposed by caries, and immediate pulp removal was performed, periapical-tissue involvement followed in a large percentage of the cases. Where an antiseptic dressing was sealed in the cavity for a period of twenty-four hours and the pulp removed at the second sitting, the periapical tissue nearly always appeared normal in the check-up radiogram. *The conclusion arrived at was that all cases of cocain pressure anesthesia should be preceded by an antiseptic dressing, so as not to force infection lying in carious dentin or upon the surface of*

the pulp through the apical foramen to infect the periapical tissue. It is also quite likely that the solution used in cocain pressure anesthesia is frequently too strong. Bastedo states, in his Materia Medica, Pharmacology and Therapeutics, that "cocain is a general protoplasmic poison, capable of irritating and destroying cells, or of stopping the motion of leucocytes, amebae and ciliated cells. Solutions above five per cent in strength, injected hypodermically, may result in the death of the tissue, which shows either as a necrotic area of the skin or as a sterile abscess."

Local anesthesia by infiltration or block anesthesia seems to be the safest method of pulp removal. Even by this method there is danger of periapical infection in the technique of pulp removal and, as a precaution, an antiseptic dressing should always be sealed in the tooth before removing the pulp. The use of phenol, acids, or strong alkalies, to remove remnants of the pulp and open small canals, has also been responsible for some of the destruction of tissue which shows in the radiogram as a radiolucent area soon after the canal is filled.

VII. ROOT-CANAL TREATMENT

The aseptic requirements of root canal operations are of equal importance with those in any branch of surgery. While the immediate health of the patient may not be involved as in major surgery, yet the presence of periapical infection may in the course of time have widespread effects that make it a serious offence needlessly to follow methods that are questionable. A single weak link in our chain of asepsis may counteract all the pains taken in every other step of the operation. Some recommend immediate canal filling, to reduce the danger of periapical infection (7). While this seems to be a reasonable argument, there are several strong reasons against this course. Where the apical foramen is large, it is more difficult to prevent overfilling while the tissue is under the influence of an anesthetic. Again, it would be too severe upon most patients to sit long enough for the operator to remove the pulp thoroughly and prepare the canals for filling. I prefer to make two sittings and rely upon a mild antiseptic dressing such as oil of cloves to keep the canal in a good condition for filling at the second sitting. In regard to the filling of the canal, I have nothing new to offer. There will always be a variance of methods

in technique. It matters little whether the canal is filled with one piece of gutta-percha or several, or whether the gutta-percha is used in one form or another, so long as the canal is completely filled to the dento-cemental junction with a dense mass that will not shrink and leave open spaces for bacterial development. Over-filled canals are more susceptible to apical tissue pathology, and great care should be taken to guard against injury to the cemental attachment of the peri-cemental tissue by forcing any foreign material beyond the dento-cemental junction. It is more difficult to fill the canal that has a large apical foramen without over-filling than to enlarge and fill the small canal successfully. To verify the success of one's method of root-canal treatment and filling, it is necessary to check up a great number of canal fillings by radiogram after a period of time has elapsed, and observe the condition of the periapical tissue. Such reports, if carefully made from accurate and complete case histories, will be of great help in clinical procedure, just as the reports of the research laboratories are furnishing the light for us at the present time by microscopic evidence.

VIII. PULPLESS TEETH

The treatment of pulpless teeth, where the periapical tissue has become involved and shows a radiolucent area about the root apex, is a different problem. The root canal can be mechanically cleaned and, by judicious use of antiseptic drugs, it can be put into a satisfactory condition for safe filling. However, the periapical tissue that is pathologic needs much consideration, and no result can be determined until sufficient time has elapsed after the treatment to observe its changes.

There is a diversity of methods of treatment of the periapical tissue, each seemingly successful from the reports given. This variance is referred to in an editorial of one of our leading journals (5) as "the anomalous, not to say uncertain position in which we find dental practice today." It seems, however, that iodin is becoming more generally used as the treatment where periapical-tissue regeneration is desired. It matters little whether Churchil's tincture, Lugol's solution, or the official tincture is used, as far as the result obtained is concerned. I use the official tincture of iodin without ionization

and find the results very gratifying. No drug that will coagulate albumin and cause tissue destruction should be used in any canal treatment. The successful treatment of canals of this class is dependent upon the condition of the apical cementum. If the cementum is denuded and suppurative products have destroyed the cementoblasts of an area of the root, no amount of treatment can cause a regeneration of tissue over such an area. Dr. Noyes states (10) "that infection passing through the foramen does not spread along the surface of the root but passes out between the fibers, following the course of the vessels, especially the lymphatics." He also states "that the surface of the cementum is the last area upon which these tissues are destroyed and it seems to me that is one of the items of hope in our problem." It is not possible to determine, in the diagnosis, whether there is a destruction of tissue on the surface of the cementum; but, with this thought in mind, by extraction one can eliminate certain types of conditions, with large, distinct and well defined outlines of bone absorption about the root apex. The small radiolucent areas and those of indistinct outline will very often clear up entirely after proper treatment. The sacrifice of useful teeth because of suspicion only is not consistent with the best methods of practice, and it is a serious mistake to deprive a patient of a useful tooth unless it is hopelessly diseased. Black says (1) that teeth are too often sacrificed on suspicion and that "the determination whether or not to extract the tooth will nearly always require a demonstration that the cementum of the root has been denuded." Careful treatment and complete records of these cases, together with subsequent examination by radiogram, will soon reveal the conditions, and many teeth will be retained that would otherwise be sacrificed.

IX. SUMMARY

(1) It is necessary to have faith in the possibilities of saving teeth with exposed pulps and pulpless teeth that will respond to treatment. The basis upon which pulpless teeth with periapical tissue involvement can be made healthy is that the cementum be protected by live tissue. It is not easy to determine this, but careful study of radiographic evidence is of great help in determining whether treatment should be undertaken or not. The condition of the patient's health,

the age of the patient, and the importance of the tooth in the reconstruction of the mouth, are other factors to be considered in determining what teeth shall be saved.

(2) Careful and aseptic technic has been and always will be the greatest factor in successful root-canal operations. The use of every precaution to prevent infection of the periapical tissue is necessary; and any injury, whether mechanical or chemical, is harmful to the health of this tissue. Caustic and irritating drugs are contra-indicated.

(3) Pulp removal is preferable to acute alveolar abscesses. When operating upon a pulp covered by carious dentin, or exposed, precaution should be taken against periapical infection by sealing an antiseptic drug over the pulp for twenty-four hours before pulp removal. All foramina are formed by cementum and the pulp lies within the dentin. Vital tissue lining the cemental foramina should not be disturbed.

(4) The success or failure of root-canal filling can only be determined by subsequent examination by radiograph. These check-up examinations should be made every year or two, or until assurance is established that the periapical tissue is healthy.

The saving of useful teeth is worthy of our best service. The success of a large percentage of root-canal fillings can be assured, if the teeth are treated in conformity with the teaching of the latest histological research. The great service to humanity that has been rendered by such research cannot be overestimated. Now it remains for the clinical force to conduct their operations so that every act will be consistent with the knowledge given us.

REFERENCES TO LITERATURE

(1) Black, Arthur D. 1919 Preventive treatment of chronic infections involving the alveolar process, *Dental Summary*, October.

(2) Black, Arthur D. 1923 What teeth should be extracted, *Dental Summary*, March, p. 183.

(3) Blayney, J. R. 1922 Clinical results of pulp treatment, *Journal of the American Dental Association*, March, p. 198.

(4) Coolidge, Edgar D. 1922 Some interesting tendencies in root-canal filling, *Dental Summary*, June, p. 475.

(5) Editorial 1922 Individualism in dentistry, *Dental Cosmos*, July, p. 775.

(6) Grove, Carl J. 1921 Nature's method of making perfect root fillings following pulp removal, with a brief consideration of the development of secondary dentin, *Dental Cosmos*, lxiii, p. 968.

(7) GROVE, CARL J. 1923 Pulp removal to prevent periapical infection, *Journal of the American Dental Association*, February, p. 94.
(8) HATTON, EDWARD H. 1922 The possibility of apical regeneration after root-canal filling, from the histo-pathological point of view, *Journal of the American Dental Association*, March, p. 192.
(9) NOYES, EDMUND. 1922 Fifty years of root-canal filling, *Transactions of the Illinois State Dental Society*.
(10) NOYES, F. B. 1921 Structural characteristics of the root apex, *Journal of the American Dental Association*, January, p. 18.
(11) THOMAS, N. G. 1921 Formation of the apices of teeth, *Journal of the American Dental Association*, January, p. 16.

DISCUSSION

M. L. Rhein, M.D., D.D.S. (*New York City*): It is a great honor to the Section on Pathodontia to welcome among its lecturers a man who has distinguished himself as has Dr. Coolidge in the specialty that has been the basis for the foundation of our Section. We can assure Dr. Coolidge of one thing—that we are in thorough accord with him as to the advisability of strenuously combating the evil of unnecessary extraction of teeth. While we may differ in many of our views on the subject under discussion, nevertheless he and the Section are united on the desirability of maintaining in the jaws pulpless teeth which show no pathologic lesion in their immediate environment.

We recognize the right of difference of opinion as to the method of accomplishing certain results. Who that has studied the wonderful mechanism of the human body, and its working in health and disease, is bold enough to feel that only his method can produce a successful issue? A short time ago a vicious "yellow journal" attack was made against the manner of discussing scientific problems by the First District Dental Society. We were severely criticized for not showing sufficient courtesy to visiting dentists, and for the wrangling discussions that took place on our rostrum. To my mind no greater praise could be bestowed upon our Society than that we had broken away from the old tradition of covering our guests with pails of soft soap and never disagreeing with the views that they might present. This classic method of professional treatment has been the great stumbling block in the path of dental evolution. There is no reason why, in the earnest endeavor for truth which should always be uppermost in the minds of professional men, we should not be able to express the strongest opposing views on any subject without in any way endangering any existing friendship. Let this be the slogan of dentistry, and it will do more to forward progress than the rehashing of that statement of Dr. Mayo's, that the next

great move must come from the dentist. I hope that our distinguished guest will realize that, while we agree with the major part of his utterances, there are many points in his estimable paper with which we thoroughly disagree. We may be right and we may be wrong; but, knowing Dr. Coolidge as I feel I do, I am sure that the expression of these differences will have no effect upon our personal relationship.

When the essayist speaks of the many successes in root-canal therapy of thirty and forty years ago, he has said something of great value. I would strongly emphasize the statement that he made, that these successes were due to the very great care which the operators of that period took in work of this kind. In my recollection there were more great men in dentistry in our country forty years ago than we find today—men who were not so much actuated by the sordidness of commercialism, men who were willing to devote every minute necessary to successful accomplishment, men who were big enough to recognize that absolute cleanliness in the person of the operator and his armamentarium was needed for successful root canal operations. If I were asked to state the greatest individual point for successful results in root-canal therapy, I would unhesitatingly reply, "asepsis." Surgical asepsis, as we know it today, is only about forty-two years old in the United States. Before that time we relied on de-odorizers, embalming agents, and so-called antiseptics to camouflage us into the belief that we were using aseptic methods. It was at this period in 1882, very early in my career, that I had the good fortune to welcome Sir Lawson Tait of Birmingham to this country, and to accompany him to Albany, where I assisted him in a number of ovariotomies. This was, I believe, the first exposition of the present acceptation of surgical asepsis in America; and, upon my return to New York a few days later, I immediately introduced this principle into root-canal therapy. In the furtherance of this principle, at this period in 1882, I introduced the solution of bichloride of mercury in hydrogen peroxide for the irrigation of root canals, and have never since that time used any form of phenol or de-odorizing medium in root-canal therapy. I have no recollection of operating on any root canal without the use of the rubber dam since the day, in 1882, when I began boiling all my root-canal instruments prior to using them.

It might be well to emphasize the value that the essayist places on a correct diagnosis of root-canal cases, with special reference to those where the pulp has been dead for a long time. Personally, I think the essayist places too great an importance on the so-called histories of these cases. In the first place most of these histories are more or less obscure, especially as to minute details of procedure. Generalities of form of procedure mean

very little from a diagnostic point of view. Successful roentgenograms taken from every possible angle, before anything is done, are unquestionably of the greatest diagnostic value. There are two points about a successful roentgenographic diagnosis. First, we must realize the utter unreliability of a picture focused only from one angle, and must have it taken from every possible angle. Second, each of these pictures must be a more or less ideal roentgenogram. Good technicians are continually obtaining pictures which, by one accident or another, have some inherent defect that prevents a proper study of the picture; and all pictures that fail to be of first-grade quality of reproduction should be thrown into the discard.

Having satisfied ourselves as to the histological conditions that are present, our next and perhaps most important step is to determine the existing physical condition. For this purpose it is important to obtain a history of the patient's physical condition as to defects or diseases that have existed or are present. We must determine whether the patient has in any way been injured from the presence of this pathologic condition of the alveolar structure. With this object in view, it is most important not only that a thorough physical examination of the patient be made by a competent internist, but also that there should be the most thorough urinalysis and blood examination at the same time. When the presence of malnutrition complications can be set aside, or injuries to any important organs, then the restoration of pulpless teeth to a condition where they can not be a menace to the rest of the body can be safely undertaken. If, however, we find some type of malnutrition, or some important organ like the ear or the eye involved directly from some focal infection, it then becomes a matter of serious judgment whether the system can stand the rigorous treatment needed in root-canal therapy. While we are unalterably opposed to the needless extraction of teeth, it is wise to remember that in a choice between the value of the heart, or the eye, or the ear, and the tooth, it is always wiser to lose the tooth rather than to impair some important function or risk a complication that will shorten the life of the individual.

It is the ability to distinguish between cases where there is sufficient immunity and those in which this immunity is lacking that really constitutes the successful diagnostician. It is my experience that this ability is a natural possession which cannot be acquired by education, and is an inherent part of the makeup of the fortunate individual who possesses it. A very interesting case in my practice last Spring illustrates a phase of this question of diagnosis. One of the prominent musical directors in the country came to me for consultation in regard to his mouth. He was at the same time suffering greatly with ear trouble, so that for a period of

six months his hearing had been becoming more and more impaired. His ear specialist was making plans to put him in a hospital for a serious operation, which I personally could not appreciate. By some peculiar intuition the patient of his own accord wondered if the bad condition of his teeth on the right side might not have something to do with the failing condition of his hearing on that side. We found the two molars and bicuspid—all three—involved with granulomas at the end of their roots. Realizing at once the possibility that this condition was the direct cause of the deafness, which was increasing daily, and the supreme importance of good hearing to a musical director, I cast aside any idea of attempting to save these teeth, but within twenty-four hours had thoroughly removed all traces of alveolar pathology from this portion of the jaw. The improvement in his ear condition manifested itself almost immediately. He did not go to a hospital for any operation, and today his hearing has become normal.

In like manner, if a patient shows the presence of severe nephritis or heart disease, it is a question whether his vitality and endurance are sufficient to warrant root-canal therapy. It is the lack of good judgment among capable root-canal technicians on this point of insufficient immunity that has given the greatest amount of ammunition to the members of the "100 per cent club." The knowledge that we can derive from expert blood examinations is increasing daily. The differential blood counts, and the comparative amounts of uric acid in the blood, are well known clinical factors at present, and I have no doubt that their value will be further increased when we have a more complete chemical knowledge of the blood. We can, however, fearlessly state that there are very many cases of pulpless teeth that can be left in a condition of more security to the individual than some with living pulps, and we unanimously and unhesitatingly decry the absurdity of speaking of a pulpless tooth as necessarily a dead tooth.

It is a satisfaction to endorse the view of the essayist as being opposed to pulp-capping, and his reference to the value of the removal of many living pulps. The ignorant clamor for general tooth extraction by many physicians who are unable to diagnose the maladies of their patients, has brought about among dentists a strong feeling against disturbing the pulp of any tooth so long as it responds to a vitality test. The public today is very likely suffering to an unheard-of degree from the retention in teeth of diseased pulps which forty years ago, according to my recollection, would have been unhesitatingly removed by men who were naturally constituted to be dentists. Henrici's valuable contribution, showing the large percentage of living pulps that are infected, should open our eyes to the importance of not leaving such pulps in the teeth. This is one of the most

difficult lessons for the dentist of today to learn, that there are very many teeth with diseased pulps in which it is essential that either the pulps or the teeth should be removed, if we are to consider the welfare of the patient.

It was a pleasure to note the author's objection to immediate root filling after living pulps have been removed. He modifies it by stating that he would fill the canal at the following sitting. I have never found a root canal in which a living pulp has been removed that I felt safe in filling at the following sitting. This is due to the fact that our objectives are different. While we insist that every portion of organic material in the canal must be removed and replaced with a solid, homogeneous mass of gutta-percha which shall hermetically seal every orifice, Dr. Coolidge not only finds this unnecessary, but objects to too tight a filling. In our opinion a filling cannot be too tight to avoid the danger of infection against which we are especially warned by the essayist.

Agreeing thoroughly with Noyes' description of the cementum, we feel that we must disagree entirely with the deductions made by Dr. Coolidge against wounding the periapical tissue. When he mentions Noyes, as his authority, he quotes what actually demonstrates the safety of aseptically wounding the periapical area. Noyes' statement is thoroughly borne out by my observations, carefully made for over forty-three years and much more positively determined during the past twenty years, since we have had the benefit of x-ray checking, and has been the basis upon which our encapsulating surgery has been built—the fact that the periapical region can be freely injured without disturbing the pericemental membrane. In our opinion the essayist confounds the results of aseptic traumatism to the periapical region with infection of this region. This error is very likely due to the difficulty of wounding the delicate periapical tissue without infecting it at the same time. When Schreier's sodium-potassium is used for the destruction of every remnant of organic tissue, it is automatically impossible to infect the periapical region because no infected substance remains in the canal. It is a surgical axiom that if a portion of any tissue is removed, it will invariably regenerate unless infection takes place. The best illustration of this is the callus formation following a fracture. I know of no exception to this rule. It is on this account that we fearlessly destroy part of the alveolus in order to seal foraminal openings hermetically. We also believe in frequent x-ray surveys of our root-canal work, and we find that our regenerated alveolar tissues remain ideal. When we fail to obtain alveolar regeneration, we look upon our operation as a failure and resort to apicoectomy or extraction.

There should be no wavering in our diagnosis of failure, if regeneration

has not occurred in a reasonable time. Root-canal surgery will never reach its proper recognition until it is generally admitted that failure to obtain absolute regeneration of destroyed alveolus indicates that the operation has not been a success. Nothing in the history of the case can alter the premise that regeneration of missing alveolar bone must occur in successful operations. When we use sodium-potassium, it finds its way into every crevice, into every byway and path leading to any number of multiple foramina. The organic tissue is virtually cremated; and when the gutta-percha canal filling is inserted by mortarization, the gutta-percha is carried equally to the end of every opening, and not only to the end of the central foramen. One anatomical fact must not be lost sight of, and that is that the histological anatomy of root ends has many variations, especially as to the diameter of the foramen and the thickness of the lamellae of cementum, which frequently keep forming upon the ends of roots. In a small percentage of cases, owing to excessive pulp irritation, the lamellae have practically obliterated the foramina. In such cases the technic of forcing gutta-percha as far as possible is permissible; and even here, if the actual foramen could be penetrated, it would be preferable. This type of operation requires much more frequent x-ray observation than where encapsulation has resulted.

In all cases of pulpless teeth we must ever remember that miraculous successes have very little real significance, so far as confirmation of the success of any particular technique is concerned, because of our inability properly to estimate the prevailing *immunity*. How long may infection have been present before showing any alveolar destruction? How much toxin is being absorbed and what part of the body is succumbing to the absorbed poison? These questions are almost unanswerable in the incipient stages of infection. Let it be understood that, as in every other branch of surgery, there is always a percentage of failures; but we repeat, what we have so often said and what has been confirmed by many x-ray surveys, that "the crux of success in root-canal therapy consists in successful encapsulation." If encapsulation is correct in operating for pulp removal, how much more positive is our need for it in root-canal cases where periapical infection exists? The practical eradication of periapical infection is an essential factor before root-canal filling. This should have substantial laboratory confirmation before its success can be claimed. The topical application of iodine or any other remedy must necessarily fail to act on the deeper portions of infected alveolar structure. After thirty-four years in the use of electrolytic medication, I am convinced it is invaluable for the eradication of alveolar pathology. Iodine is very likely one of the most

valuable remedies that can be used, but it can only reach the deep portions of the infected area when it is forced there by electric means. I have in course of preparation a statistical compilation of the past few years' use of electrolytic medication, and it fully bears out what we have claimed.

Once more we disagree with the statement that, because the end of the root has lost its pericementum and the cementum is partly absorbed, the tooth cannot be successfully treated. If the alveolar pathological condition has been eradicated and the exposed cementum entirely covered with gutta-percha, we shall have as successful a result as can be desired. We say this with the assurance of success in cases which have been under years of x-ray observation. By no means do we desire to decry the possibilities of success by other means, but we do deny the right of any one to condemn our technique and question our results without proper investigation by properly qualified dentists, and that excludes the majority of our colleagues.

In conclusion permit me to say that the substantial benefits of scientific root-canal therapy will never reach the public until this branch of dentistry becomes as highly specialized as orthodontia.

C. William Rubsam, D.D.S. (*New York City*): Though I shall differ with our essayist on a few points, I wish to say that a long time has elapsed since I have read a paper on this subject that has appealed to me as being so sane and well taken as has this paper. Our essayist makes no extravagant claims for the efficacy of any pet technique; he holds out no hope for the teeth with considerable areas of periapical involvement; and, above all, he has had the good sense to put his ear to the ground and welcome some teaching by our histologists. I am always inclined to put trust in the man who is ready to look beyond his own horizon for advice; and, between the lines of this evening's paper, one reads the slight uncertainty, the willingness to admit that failure is possible, and that the last word in technique has not been spoken. I knew that time would not permit a lengthy discussion so I shall merely touch upon several major points of the paper.

The first is that of completely filling a canal to the dento-cementral junction with the express purpose of shutting out bacterial life. This presents a mechanical problem with finite limitations of space and matter. These are concrete factors leading to the science of measurement. However, it is amazing with what naive innocence we have completely ignored the science of mathematics in our canal filling. We will admit that to fill a root against microbic invasion is a mechanical procedure. Then can you conceive of any mechanical operation that is not related to the science of mathematics, either expressed or implied? A six-inch mesh wire may be

all right for confining a flock of sheep, but of what use is it in keeping a flock of ducks in an enclosure? In exactly the same manner, your gutta-percha root filling to, through, beyond the apex is sufficient to produce a radiographic result showing precision in filling. But does that mean that it holds back the microbic form which ranges around one fifty-thousandth of an inch in diameter? Are we not presuming a great deal when we assume that our naked eye can discern in a radiograph a discrepancy about a root-filling small enough to permit the passage of microbic life?

This is too preposterous to be worthy of critical consideration, and yet on this delicate point hinges the efficacy of root filling. The undisputed fact remains that the apical tissue at many a carefully filled root in the past has remained normal through the years. From this it was deduced that a mysterious potency in our root work was the cause. I believe this to be utterly fallacious. The failure of infection to become established in that root was due, I believe, to an aseptic handling of the canal and to the broad influence of immunity.

Now we find that both our essayist and my co-discusser lay emphasis on being able to seal out microbic life by a root-filling technique. Having made this announcement, the burden of proof devolves upon each of them to furnish us with microscopic—please note that—microscopic evidence of their mathematical precision in attaining this ideal result. Some of you may know how difficult it is to construct removable appliances where the standard of accuracy is on two-thousandth of an inch. Now multiply this difficulty by twenty-five and then place your field of operation into the furthermost recesses of a root canal, and only by a violent stretch of your imagination can you microscopically exclude bone fluid and microbic life. Present this case to a microscopist, acquaint him in detail with all the factors involved—the moisture around the apex, the volatility of the medium used to soften the gutta-percha, the irregularity of conformation of canal surfaces and many other hazards—and see whether he thinks our root-canal claims are reasonable?

Our essayist intimates that he uses iodine solutions in treating infected canals. May I inquire whether he uses iodine for sterilization of periapical tissue? If so, does he believe that iodine, confined in a bone cavity that way, can be depended upon to leave the healthy, living bone unmolested? Will he admit that iodine left in contact with mucous membrane in the mouth for a few minutes actually produces a slight superficial necrosis of the tissues? What must it do in bone, if confined that way until it is completely absorbed? Is not iodine poisoning a fact and not a fancy?

The use of strong disinfectants and strong chemical agents near or through

the apex has been one of the principal abominations in root work through its history. We know that surgery has long since discarded them, bag and baggage. It is said that sodium-potassium is an exception to the rule, that it cleanses tissue as does the surgeon's knife, etc. How unfortunate that our able surgeons have not the intelligence to apply this freely in their bone work, if it is so effective! Or is it possible that they have rejected such a method as totally unfit for use on human tissue?

In the matter of injuring periapical tissue, I am heartily in accord with Dr. Coolidge. Whether you burn with an acid, roast with an alkali, cremate with a coal-tar derivative, or macerate with a broach, you leave the apical tissue in a condition that impairs its vital resistance to subsequent chance contact with microbic life. The whole drift of opinion is toward this side of the subject and eventually we shall hear nothing more about treating apical lesions by tissue-destroying chemical agents or catapulting gutta-percha through the apices for their encapsulation. In regard to multiple canals, our essayist says their cleansing and filling is unnecessary, as they are lined with cementoblasts and therefore capable of closure by cemental deposition; and he says the pulp is confined to the dentine. This leads to a curious situation that you can readily visualize, and leaves pulp fragments entirely unprovided for. They must not be charred with caustics lest the pericemental tissues be injured. Would it not be of interest to hear our essayist's explanation of this phase of the matter.

It is clear that our essayist is open-minded on his subject and that most of us sympathize with him in his desire to save pulpless teeth. The "100 per cent vitality" men must come forward with more trustworthy proof than they have presented in the past, before they can convince us that all pulpless teeth are infected teeth. As matters stand, I believe our success in root-canal work occurs in spite of our ramming and cramming, not because of it.

The germ-proof root-filling has not arrived. However, let us not forget that the individual immunity that protected pulpless teeth years ago is still a living, active force and some day we may know more about making it amenable to our ends. In time, I hope to find that aseptic technique and a high immunity to periapical infection, plus the prevention of factors leading to the loss of the dental pulp, will relegate this troublesome question to the background.

X-RAY TREATMENT OF TONSILLITIS AND CHRONIC PHARYNGITIS[1]

W. D. WITHERBEE, M.D.

New York City

The extreme susceptibility of lymph tissue to the x-ray, and its immunizing effect on the tissues in local infections, are the two cardinal principles upon which the x-ray method of treatment is founded. Heinicke (1), in 1905, first pointed out the fact that lymph tissue was very readily destroyed by small doses of x-ray. Murphy and Ellis (2, 3) were able, by suitable exposures, to remove almost all of the lymph tissue in animals, without inducing detectable changes in other organs or tissue. Taylor and Murphy (6) found that, when the doses of x-rays were properly graded, even the total number of polymorphonuclear leucocytes remained unaffected while the lymphocytes fell to a point at which few are seen in the circulating blood. With our present-day methods of x-ray technique, the results obtained in lymphosarcoma, Hodgkin's disease, lymphatic leukemia, and splenomedullary leukemia are not only examples of the effects of x-ray on lymph structures, but also substantiate the fact that suitable doses remove lymph tissue without inducing detectable changes in any of the adjacent glands or tissues.

The tonsil histologically is a lymph node made up entirely of lymph follicles and connective tissue framework. The mere fact that the x-ray causes a disintegration of the lymph follicles in the tonsil, as in any other lymphatic structure, indicates not only that the size of the tonsil is markedly reduced, but also that the depth of the crypts will be greatly lessened; and that, if sufficient treatment given, only the fibrous and connective tissue framework will remain, thus leaving only the type of tissue which nature utilizes in her efforts to protect both the local tissues and the entire organism from septic absorption.

[1] Read at a meeting of the New York Academy of Dentistry, at the New York Academy of Medicine, on November 15, 1922.

The effect of the x-ray on the adenoids, infra-tonsillar nodule, lingual tonsil, and the hypertrophied and infected lymph tissue so often seen on the posterior and lateral walls of the pharynx, sometimes extending well up the Eustachian tube and interfering with the aeration of the middle ear, is identical with that obtained in the tonsil.

The immunizing effects of the x-ray on the tissues in local infections is best exemplified by the results obtained in the past in acne vulgaris, ringworm of the head and beard, carbuncle, and boils. It has been found that the infective microörganism in these cases is little if any changed by the direct action of the ray, for cultures of these bacteria show no effects after prolonged exposures. Of 36 cases in which specimens were taken from the tonsillar crypts, 32 showed an absence of pathogenic bacteria after treatment. Recently Hickey, of Detroit, has carried out this treatment in a series of diphtheria carriers in which he was able to rid the throat of diphtheria bacilli in from two to four days; and this occurred in 80 per cent of the number of cases treated. Also Ludin, of Basel, Switzerland, in a recent article, recommends x-ray therapy in tubercular peritonitis, stating that preliminary tapping is never necessary in cases with ascites; in six cases of erysipelas the fever promptly subsided and the erysipelas ceased to spread and soon disappeared.

The principle of immunization of the tissues in local infections, as indicated in the results in the above-mentioned conditions, is further verified in the results obtained in cases of chorea, rheumatism, and in patients suffering from chronic valvular heart disease with the usual history of tonsillitis and rheumatism, followed by chronic endocarditis. The removal of the local infection in the naso-pharynx by x-ray has relieved the chorea and rheumatism, and the chronic cardiacs of the constant absorption of toxic material so that they have gained in weight and are better able to follow their occupations.

The technique is comparatively simple. In the average case we use a 7-inch sparkgap, 5-milliampere current, 10-inch distance, 3 mm.-aluminum filter, and a 4-minute period. The patient lies face downward, head turned to the side, and position and angle of the patient and tube corresponding exactly to that employed by the roentgenologist in making a radiograph of the lower molars on an x-ray plate. The number of treatments is usually about eight, given at two-week

intervals, and both sides of the head are exposed at each treatment. A special table and board have been devised for the treatment of children.

The same technique, so far as the factors are concerned, is used in the treatment of tubercular glands of the neck and toxic goitre, the

FIG. 1. ILLUSTRATION OF THE USE OF THE INDICATOR IN DETERMINING THE DISTANCE AND DIRECTION OF THE RAY, SHOWING AREA EXPOSED AND POSITION OF THE PATIENT

Routine factors with this apparatus are a 7-inch spark gap, 5-milliampere current, 10-inch distance, 4-minute period, and 3-mm. aluminum filter.

only difference being in the area exposed. In the goitre cases we expose both the tonsil and thyroid gland; and in the tubercular-gland cases, the tonsils and the glands involved. Whether an infected throat has anything to do with the toxic goitre is a debatable point; however, I have seen one case, sent into the hospital with an acute follicular tonsillitis, which in 48 hours developed all the symptoms

of toxic goitre. If the infected throat has anything to do with the action of the thyroid gland, we might expect better results in these cases when the focal infection in the throat is relieved in addition to application of the ray to the gland itself. In tubercular glands of the neck the removal of the focal infection in the tonsil and throat also

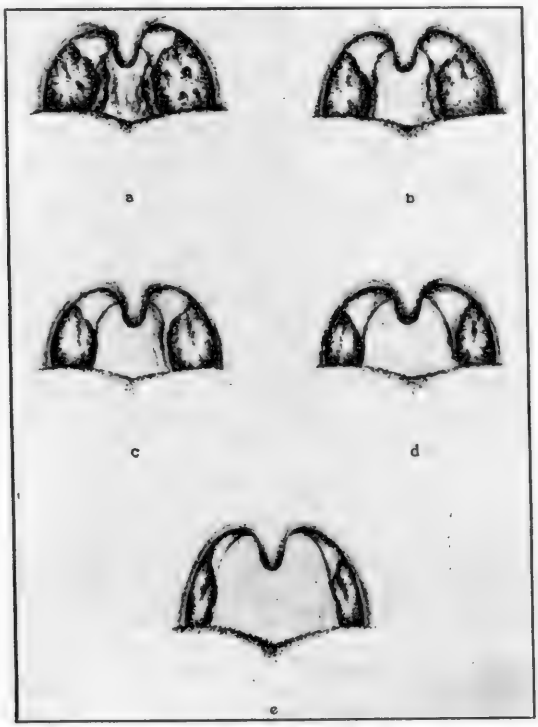

FIG. 2. ILLUSTRATIONS OF THE EFFECTS OF THE TREATMENT

a.—Tonsils before x-ray treatment. Tonsils large and ragged; crypts contain pus; there is a large mass of lymphoid tissue behind the posterior pillars.

b.—Two weeks after treatment. Size of tonsils reduced; surface smooth and clean; size of the mass behind the pillars diminished; hemolytic streptococci have disappeared.

c.—Four weeks after treatment. Size of tonsils markedly reduced; pale and smooth; no exudate on deep pressure.

d.—Eight weeks after treatment. Small amount of exudate.

e.—Six months after treatment. Tonsils small and normal in appearance; no exudate on deep pressure; lymphoid tissue behind pillars practically all removed.

relieves the primary focus of infection, and thus has a more lasting influence on the tubercular gland.

This method, compared with surgical removal of tonsils and adenoids, is free from serious complications. Following surgical removal one may have all the conditions which arise from circulating septic emboli: lung abscess, empyema, phlebitis, endocarditis, etc. Hemorrhage and middle ear and mastoid infection may also complicate recovery. In the x-ray treatment there are no known complications, provided the technique is faithfully carried out. The permanency of the results as well as the safety of this method can be checked up easily by any one who in the past ten years has had a number of tubercular glands of the neck treated by x-ray. Van Allan's recent report of 50 cases (*Journal of Radiology*, December, 1921), is most interesting and instructive.

The objections so far encountered to the x-ray method have been, first, the danger of an x-ray burn. This is impossible, if the technique prescribed is carried out. The possibility of injury to the parotid, the thyroid, the pituitary, and to other adjacent glands has been amply tested in the past ten years, in which tubercular glands of the neck have been treated by much larger doses, some of the cases receiving as high as forty doses; whereas the dose for tonsils and adenoids has never exceeded fourteen treatments in any given case, in a series of nearly 1000 cases treated in the past two years.

This method is specially indicated in chronically infected throats in vocalists, since the muscular reconstruction of the throat is at a minimum as compared with that following surgical removal of tonsils and adenoids; also in cases associated with rheumatism, chorea, diabetes, chronic endocarditis, hemophilia, or any condition contraindicating operation.

REFERENCES TO LITERATURE

(1) Heinicke, H. 1905 *Mitteilungen aus der Grenzgebiete der Medizin und Chirurgie*, xiv, 21.

(2) Murphy, Jas. B. 1914 *Journal of the American Medical Association*, lxii, 1459.

(3) Murphy, Jas. B., and Ellis, A. W. M. 1914 *Journal of Experimental Medicine*, xx, 397.

(4) MURPHY, J. B., WITHERBEE, W. D., CRAIG, S. L., HUSSEY, R. G., AND STURM, E. 1921 The atrophy of hypertrophied tonsils and adenoids and other lymphoid structures of the throat induced by small doses of x-ray. *Journal of the American Medical Association*, January 22.

(5) ———. 1921 The effect of small doses of x-ray on hypertrophied tonsils and other lymphoid structures of the nasopharynx. *Journal of Experimental Medicine*, June.

(6) TAYLOR, H. D., WITHERBEE, W. D., AND MURPHY, J. B. 1919 *Journal of Experimental Medicine*, xxix, 53.

(7) WITHERBEE, W. D. 1921 X-ray treatment of tonsils and adenoids. *American Journal of Roentgenology*, January.

(8) ———. 1921 The principles involved in the x-ray treatment of tonsils. *New York Medical Journal*, March 16.

(9) ———. 1922 Treatment of focal infection of the throat by x-ray, compared with surgical removal of tonsils and adenoids. *Journal of Radiology*, iii, April.

DENTAL LIBRARY

DEC 15 1925

Volume V December, 1923 Number 4

THE JOURNAL OF DENTAL RESEARCH

(Continuing the Journal of the Allied Dental Societies)

A journal of stomatology; devoted to the advancement and dissemination of knowledge pertaining to the teeth and mouth, and to their relations to the body as a whole

PROPERTY O
DENTAL LIB
UNIVERSITY OF MIC
DENTAL ANATOMY
REMOVE

EDITED BY

JOHN AUER
St. Louis
ELMER S. BEST
Minneapolis
ARTHUR D. BLACK
Evanston, Ill.
FRANZ BOAS
New York City
C. F. BÖDECKER
New York City
T. W. BROPHY
Chicago
G. V. I. BROWN
Milwaukee
J. P. BUCKLEY
Los Angeles
R. W. BUNTING
Ann Arbor, Mich.
R. BURTON-OPITZ
New York City
H. E. S. CHAYES
New York City
C. B. DAVENPORT
Cold Spring Harbor, L. I.
MARTIN DEWEY
New York City
H. H. DONALDSON
Philadelphia
WM. B. DUNNING
New York City
A. C. FONES
Bridgeport, Conn.
E. B. FORBES
State College, Pa.
CASIMIR FUNK
Warsaw, Poland
HENRY W. GILLETT
New York City
WILLIAM K. GREGORY
New York City
C. J. GRIEVES
Baltimore
E. B. HART
Madison, Wis.
T. B. HARTZELL
Minneapolis
EDWARD H. HATTON
Chicago
JOSEPH HEAD
Philadelphia
MILO HELLMAN
New York City
ARTHUR T. HENRICI
Minneapolis
ALFRED F. HESS
New York City
T. P. HINMAN
Atlanta
R. G. HOSKINS
Columbus
PERCY R. HOWE
Boston
I. J. KLIGLER
New York City
L. E. LA FÉTRA
New York City
E. V. MCCOLLUM
Baltimore
F. H. MCCRUDDEN
Boston
JOHN A. MARSHALL
San Francisco
LAFAYETTE B. MENDEL
New Haven, Conn.
ARTHUR H. MERRITT
New York City
F. B. MOOREHEAD
Chicago
FREDERICK B. NOYES
Chicago
REUBEN OTTENBERG
New York City
WILLIAM H. PARK
New York City
WESTON A. PRICE
Cleveland
M. L. RHEIN
New York City
R. H. RIETHMUELLER
Los Angeles
JOHN ROGERS
New York City
E. C. ROSENOW
Rochester, Minn.
OSCAR M. SCHLOSS
New York City
F. V. SIMONTON
San Francisco
T. A. STOREY
New York City
KURT H. THOMA
Boston
NEWTON G. THOMAS
Chicago
M. L. WARD
Ann Arbor, Mich.
F. T. VAN WOERT
New York City
B. W. WEINBERGER
New York City
WM. H. WELKER
Chicago
J. LEON WILLIAMS
New York City

JOHN OPPIE MCCALL
Editor, First District Dental Society of the State of New York

R. W. WADDELL
Editor, New York Academy of Dentistry

WILLIAM J. GIES
Member, International Association for Dental Research

PUBLISHED QUARTERLY
AT MOUNT ROYAL AND GUILFORD AVENUES, BALTIMORE, MD.
BY THE JOURNAL OF DENTAL RESEARCH, INC.
EDITORIAL OFFICE: 437 West 59th St., New York City
Copyright, 1925, by the Journal of Dental Research, Inc.

Entered as second-class matter, June 24, 1919, at the Post Office at Baltimore, Maryland, under the act of March 3, 1879

Made in United States of America

GENERAL ANNOUNCEMENTS

Discontinuance of the Abstracts of the Contents

Beginning with this volume, the abstracts of the contents of the numbers, heretofore at the head of each issue, will be discontinued. If 10 per cent of the number of subscribers request their continuance, the abstracts will be presented as usual.

Proceedings of Dental Societies to be Published as Independent Journals Within the Journal of Dental Research

Affiliated dental societies now publish their Proceedings on conditions that make each Society's section, in effect, its own independent journal under the covers of the Journal of Dental Research. Sections as they are published may be obtained as reprints, by societies, for issuance in separate volumes of Transactions. The broad import of this development, for the cause of independent professional journalism, will become apparent with its evolution in the successive issues. Information regarding the plan will be given immediately to any society that may request it.

All communications regarding the contents of the sections should be addressed to representatives of the respective societies.

Shall the Numbers be Issued Trimmed or Untrimmed

In a ballot on the preference of the subscribers for untrimmed or trimmed copies of this and succeeding numbers, only 14 per cent expressed a desire for trimmed copies. Most of those concerned have failed to vote on this particular question. The poll will remain open until a majority of the subscribers register their wishes.

Delay in the Publication of this Number

The long delay in the publication of this issue of the Journal has been explained in a circular letter to the subscribers. This number will be issued in November, 1925. The next number will be issued in December.

Important Books Received

The dentist's own book. By C. Edmund Kells, D.D.S., F.A.C.D., 1237 Maison Blanche, New Orleans. 1925: pp. 510; 7 5/8 x 4 5/8 in.; $7.50. C. V. Mosby Company, St. Louis, Mo.

The life and work of James Leon Williams. By George Wood Clapp, D.D.S., 220 West 42nd Street, New York City. With an introduction by C. N. Johnson, M.A., D.D.S., F.A.C.D., President of the American Dental Association, 1925: pp. 299; 7 1/4 x 3 3/4 in. Dentists' Supply Company, New York City.

THE ORIGIN AND EVOLUTION OF THE HUMAN DENTITION

A Palæontological Review

BY

WILLIAM K. GREGORY, A.M., Ph.D. (Columbia)

Curator of the Department of Comparative Anatomy, American Museum of Natural History, New York; Associate Professor of Vertebrate Palæontology, Columbia University

Illustrated with 15 plates and 353 figures
6 x 9 Cloth, gold stamped 548 pages
Detailed Index Full Bibliography

The Origin and Evolution of the Human Dentition is a masterly review of the palæontological facts relating to the origin and evolution of the teeth in man, by one of the best informed investigators in this field. The book presents a complete summary of the main facts in the palæontological record on the origin and evolution of human dentition; and will be universally regarded as the most notable and successful effort to epitomize this information, to reveal its full evolutional import, and to suggest its practical significance. This review is a great fund of important facts and opinions in dental science, and must be STUDIED, particularly in close comparison of the text with the many exceptional illustrations, to be fully appreciated.

The author discusses broadly various important phases of human evolution in general.

Of special interest to dentists, physicians, palæontologists, odontologists, morphologists, and students of evolution and inheritance.

CONTENTS

Part I. Traces the stages of ascent from the Silurian fishes to the mammals of the Age of Reptiles.

Part II. Covers the stages from the Paleocene placental mammals to the lower primates.

Part III. Describes Nature's earlier experiments in evolving large-eyed and short-jawed primates.

Part IV. Discusses the dentition of the higher primates and their relationships with man.

Part V. Treats the later phases in the evolution of the human denture; gives a conspectus of the species and the chief races of mankind, with special reference to dental characters; and concludes with a general summary of twenty-six structural stages in the ascent of man and in the evolution of the human dentition.

A detailed index and a full bibliography are included.

NOTE: The author has generously arranged for the sale of this book under conditions that will give the proceeds to the Endowment Fund of the Journal of Dental Research.

Price: $6.00 net

May be ordered from

THE WILLIAMS & WILKINS COMPANY

Publishers of Scientific Journals and Books

BALTIMORE, U. S. A.

See the reviews on pages 275-280.

INFORMATION FOR PROSPECTIVE SUBSCRIBERS OR CONTRIBUTORS

THE JOURNAL OF DENTAL RESEARCH is dedicated to the advancement of scientific stomatology in all its aspects, and to the promotion of research in dentistry in particular. It publishes original investigations and reviews in these fields, and in the sciences allied with or applied to them. It is issued quarterly, at the *ends* of the months of March, June, September and December. Each volume contains at least 500 pages.

This JOURNAL has no "policy." It represents an unwavering purpose to keep widely open the channel to freedom of *responsible* and *respectable* expression of truth and opinion, in dental affairs, without qualification by or for any views its editors individually may entertain.

The JOURNAL OF DENTAL RESEARCH circulates widely among the most enlightened and progressive dentists and physicians, and among the leading libraries, thus assuring the degree and quality of publicity for its contents that the best dental literature merits. There can be no important occasion, therefore, except in very special cases, for the detailed presentation elsewhere of a paper published in this JOURNAL. Accordingly, in order to prevent waste of the JOURNAL'S resources in needless duplicate publication, and also to lighten the labors of students of the literature of dentistry, papers in this JOURNAL (copyrighted) are not published in, or reprinted from, other dental journals, except for unusual professional reasons, and then only by definite formally acknowledged agreement.

The subscription price of this JOURNAL is $5.00. Remittances should be made *by draft or check on New York*, or *by postal money order*, payable to the JOURNAL OF DENTAL RESEARCH, INC.

Authors of papers *on original research* will receive, free of charge, 50 reprints of their papers, *if they desire them*. Copies in any number may be obtained at prices that will be quoted on request.

Address business communications to THE JOURNAL OF DENTAL RESEARCH, INC., Mount Royal and Guilford Avenues, Baltimore, Md.

Address communications relating to editorial matters to THE JOURNAL OF DENTAL RESEARCH, 437 West 59th Street, New York City.

CONTENTS

DECEMBER, 1923

R. W. LEIGH, A.B., D.D.S. Histopathology of dental caries, and its periapical sequelae (New York Academy of Dentistry) 197

ISADOR HIRSCHFELD, D.D.S. A study of skulls in the American Museum of Natural History, in relation to periodontal disease (American Academy of Periodontology) 241

RICHARD R. PRICE, Ed.D. Extension courses in dentistry: a contribution to research in dental education 267

Reviews of Gregory's book on the origin and evolution of the human dentition 275

SCIENTIFIC PROCEEDINGS OF DENTAL AND STOMATOLOGIAL SOCIETIES cxxxvii

First District Dental Society of the State of New York:

FREDERICK A. BRICKER, D.D.S. Education as a factor in the rising tide of preventive dentistry cxxxix

W. A. JAQUETTE, D.D.S., FREDERICK S. MCKAY, D.D.S., AND ARTHUR H. MERRITT, D.D.S., F.A.C.D. Discussion of the paper by Bricker cxlviii

THOMAS J. BARRETT, A.M., D.D.S., F.A.C.D. Notes on an ethical question in dental science clix

E. L. KEYES, M.D. Discussion of the paper by Barrett clxv

EDGAR D. COOLIDGE, D.D.S. Root-canal treatment clxvii

M. L. RHEIN, M.D., D.D.S., and C. WILLIAM RUBSAM, D.D.S. Discussion of the paper by Coolidge clxxvii

New York Academy of Dentistry

W. D. WITHERBEE, M.D. X-ray treatment of tonsillitis and chronic pharyngitis clxxxvii

WAVERLY PRESS, INC.

BALTIMORE, U. S. A